Title: 2010 Concepts of Operations Document	**Date:** July 2002	**Document Owner:**
Document No.: SATS 01-029	**Version:** 1.0	Sally C. Johnson

National Consortium for Aviation Mobility

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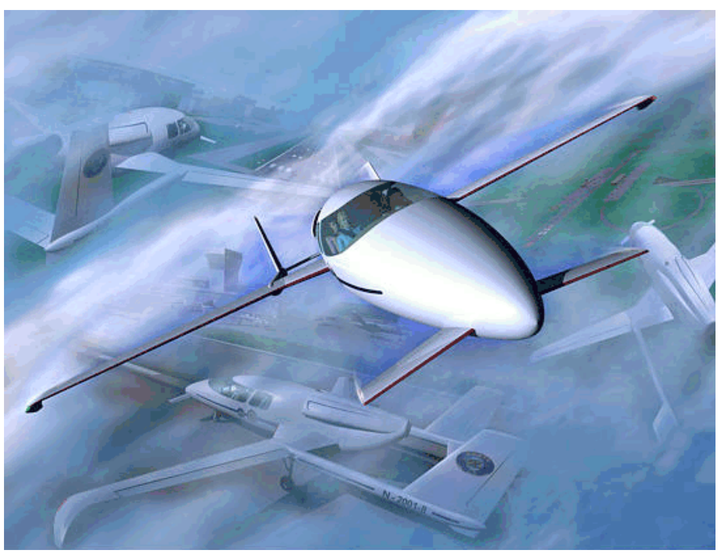
SMALL AIRCRAFT TRANSPORTATION SYSTEM PROGRAM



2010 CONCEPTS OF OPERATIONS DOCUMENT

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REVISION HISTORY TABLE

Revision	Date	Description
CRD	March 2002	Coordination Draft
V1	July 2002	Version 1.0

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1.0 SCOPE

1.1. INTRODUCTION

This document supports the development of a set of 2010 Concepts of Operations envisioned to accomplish the objectives of the SATS project. The goal of the five-year SATS Project is to take the first steps towards the long-term SATS vision by developing key airborne technologies to provide an integrated technology evaluation and validation. The project has four objectives centered on enabling operational capabilities:

- <u>Higher Volume Operation at Non-Towered/Non-Radar Airports.</u> Enable simultaneous operations by multiple aircraft in non-radar airspace at and around small non-towered airports in near all-weather.
- <u>Lower Landing Minimums at Minimally Equipped Landing Facilities</u> Provide precision approach and landing guidance to small airports while avoiding land acquisition and approach lighting costs, as well as ground-based precision guidance systems such as ILS.
- <u>Increase Single-pilot Crew Safety and Mission Reliability.</u> Increase single-pilot safety, precision, and mission completion.
- <u>En Route Procedures and Systems for Integrated Fleet Operations.</u> Provide simulation and analytical assessments of concepts that integrate SATS-equipped aircraft into higher en route air traffic flows and controlled airspace.

These objectives will be met through the following technical approach:

- A set of proposed concepts will be identified and developed to enable the four operational capabilities. These will be referred to as 2010 Concepts of Operation (ConOps) because they define how the operational capabilities would be met with an operationally deployed system in the 2010 timeframe. Many alternative concepts will be explored early in the project for enabling each of the operational capabilities. As the project progresses and early performance and operational feasibility studies are completed, the project will gradually downselect and further integrate into only a few integrated concepts.
- Key technologies and procedures will be developed to support the creation and evaluation of the ConOps. The technologies and procedures to be developed in the project are derived from the technical requirements of the ConOps.
- Laboratory, simulation, and flight experiments will be conducted to evaluate the performance and the technical and operational feasibility of the enabling technologies and procedures and the integrated ConOps.
- Products of the project will include design guidelines and recommended system standards as well as identification of certification issues for the enabling technologies and procedures.
- The project will also produce the systems-level analysis and benefits studies needed to provide the technical and economic basis for national investment and policy decisions

related to further development and deployment of a small aircraft transportation system.

1.2 PROGRAM OVERVIEW

The technical management of the SATS program will progress through 5 phases:

- Concept Development: Development of multiple strawman ConOps for each of the four operating capabilities.
- Initial Development: Development of key prototype algorithms, technologies, and procedures and conduct of selected analyses, simulations, and flight tests necessary to support evaluation of the technical and operational performance of the ConOps.
- Higher Volume Operations and Lower Landing Minimums Development: Downselect of initial ConOps based on initial study results and integration into one or two ConOps each for the higher volume operations and lower landing minimums operational capabilities. Continued development of key prototype algorithms, technologies, and procedures and conduct of selected analyses, simulations, and flight tests necessary to support evaluation of the technical and operational performance of the ConOps.
- Refinement and Integration: Downselect of HVO and LLM ConOps based on study results and integration into one or two project-wide ConOps to carry through to integrated flight evaluation and demonstration. Continued development of key prototype algorithms, technologies, and procedures and conduct of selected analyses, simulations focusing on concept integration. Conduct of one or more integrated flight tests to evaluate the technical and operational performance of the integrated ConOps.
- Demonstration and Closeout: Conduct of integrated flight demonstration of the integrated ConOps. Final documentation of the concepts, technologies, procedures, and evaluation results.

1.3 DOCUMENT OVERVIEW

The purpose of this document is to capture the Concepts of Operations being explored during the project. The nature of this living document will evolve over the life of the project. Early in the project, multiple Concepts of Operations will be explored for each of the SATS 4 operational capabilities. These initial Concepts of Operations will be distinguished by operational capability, and then by phase of flight. As the project progresses, the Concepts of Operations will be integrated first around the first two operating capabilities and then into SATS-wide concepts. Also, the number of concepts to be explored will be reduced through a series of downselect decisions based on early performance and feasibility research results.

Appendix A of this document contains the baseline operational concept for the 2005 showcase technology demonstration. The baseline operational concept was jointly defined by NASA and NCAM to represent functionality that can conservatively be expected to be developed to TRL-6, evaluated in integrated flight evaluation, and included in the 2005 technology flight demonstration within the budget, schedule, and staffing of the SATS program. The baseline operational concept will be periodically revised during the program to incorporate results of studies and analyses, but will be frozen at the beginning of the Demonstration and Closeout phase of the program.

1.4 REFERENCE DOCUMENTS

1.5 BACKGROUND

The nation's commercial air transportation system has reached a capacity plateau and demand for transportation services continues to steadily increase. Nearly 96% of domestic air travelers are forced to fly through fewer than 500, and 70% through fewer than 35 of the Nation's more than 18,000 landing facilities. One approach to increasing total system throughput and capacity lies in expanding access to more than 5,000 of these underutilized smaller airports. Most of these airports today have no control towers and lie outside air traffic control radar coverage. They are not suitable, without significant investment, for use by the airlines that provide most of the country's transportation service today, but have a unique potential to provide new, convenient access and service to small cities and communities across the country. New, small, efficient aircraft equipped with NASA developed technologies to safely use these airports in near all-weather could provoke point-to-point on-demand and scheduled transportation at speeds three or four times faster than highway speeds. The new access and mobility that this would create is critical to future development, community vitality and economic opportunity that increasingly depend on access to rapid point-to-point transportation. Today, communities with airports capable of handling smaller aircraft in near all-weather conditions create significant economic benefits compared to communities that are not served by such landing facilities. The Small Aircraft Transportation System (SATS) Project long-term vision contemplates inter-modal connectivity between public and private, air and ground modes of travel, in essence a true integration of the National Airspace System with the interstate highway system, intra-city rail transit systems, and hub-and-spoke airports.

2.0 CONCEPTS OF OPERATIONS FOR HIGHER VOLUME OPERATIONS

2.1 CONCEPT HVO-A

The general philosophy underlying this Higher Volume Operations (HVO) Concept of Operations is the establishment of a newly defined area of flight operations called an HVO Airport Operations Area (AOA), which will surround a newly designated HVO airport. This airport operations area would be defined for each specific airport, and take into account things like terrain, obstacles, local traffic density, and noise abatement procedures. Inside this zone, free flight and self-separation between HVO equipped aircraft as well as flights conducted under traditional Instrument Flight Rules (IFR) are permitted in Instrument Meteorological Conditions (IMC). These HVO airports will be some of the non-towered, non-radar controlled airports that currently have limited or no operations in IMC.

Assuming an IFR arrival to an HVO airport in IMC (under ATC control), HVO equipped pilots will be permitted to request an HVO clearance and take responsibility for separation assurance from other HVO aircraft once inside the HVO AOA. Aircraft operating under IFR will also be permitted to land at an HVO airport with certain requirements, and under certain procedural guidelines. This is addressed in more detail in the section entitled mixed equipage.

What follows is a brief description of what HVO operations might look like in the year 2010, along with high-level concepts for operational procedures.

The following are the major assumptions made in the formulation of this concept of operations:

- The concept of an HVO Airport Operations Area is operationally feasible.
- All HVO aircraft have a minimum set of equipage, which is defined to include: an ADS-B transceiver, GPS, CDTI, data link and automated conflict detection.
- Within the HVO AOA, HVO pilots must assume responsibility for self-separation.
- The HVO airport has an Airport Management Module for sequencing that exchanges data with HVO pilots and ATC.
- The HVO airport must have weather observing/reporting capability.
- These operations are conducted in IMC.
- In the en route phase of flight, if the aircraft is operating under IFR it is assumed the aircraft is under positive ATC control.
- These operations are conducted under FAR Part 91 as much as possible.
- There is no special provision required for separation from VFR traffic ("see and avoid" in effect per FAR Part 91.113).
- All approaches are approved, "published" approaches (they may be sent up from the ground from a pre-approved set but they are not dynamically calculated in the air).
- The goal of this concept of operations is to facilitate achieving the program target goal of allowing 10 simultaneous operations in non-radar airspace.

2.1.1 Departure Phase

Prior to departure, the pilot of the HVO aircraft will file either an HVO only, or an HVO/IFR/VFR combined flight plan. The combined plans will look something like today's VFR/IFR composite Flight Plan with minor variations. An HVO/IFR combined plan would include an HVO portion covering the areas occurring in HVO governed airspace. The IFR portion of the plan would take care of the en-route portion of the flight, where the aircraft would be under positive control. It would also be possible to file an HVO/VFR combined plan, where once outside the HVO governed airspace, the aircraft would fly under VFR. An HVO only plan would allow for HVO equipped aircraft to fly between overlapping HVO airports without entering ATC controlled airspace. Initially, a pilot would file the flight plan using any of the currently available traditional methods. However in the future, it is possible they will be able to do so via data-link from their aircraft.

In continuing preparation for departure, an HVO equipped aircraft would transmit a data-link message, containing several departure parameters, to an Airport Management Module (AMM) located at the departure airport. Initially, these parameters will include, but may not be limited to, the pilot's specific choice from a set of predefined Departure Fixes (DF), a Requested Time of Departure (RTD), and aircraft type and performance information. The Airport Module will process this request, and in coordination with any necessary Air Traffic Control authority, assign the requesting aircraft both a departure window, and a sequence position in departure/arrival queue. Once these assignments are made, the AMM data-links this information to the requesting aircraft.

The Airport Management Module will make this assignment based on an optimization routine that includes calculations using aircraft performance, wake turbulence requirements, other traffic, and winds in the terminal area. If the departure window, and forecast performance are adhered to, the sequence and departure window assignments will be a considerable aid to ensuring separation with other departing/arriving HVO equipped aircraft. It is important to remember that separation assurance inside the HVO AOA will be the responsibility of the pilot and that sequence numbers and arrival/departure windows assigned by the AMM are meant to significantly aid the pilot in this regard. This sequencing and provision of windows will also provide for an orderly and smooth flow or traffic into and out of the HVO AOA.

As the departing aircraft taxis to the active runway, the pilot will use a multi-function display to see his position and sequence relative to other local traffic. This display will show not only his aircraft, but also the position and sequence numbers of other HVO aircraft in the control zone. As he approaches the number one position for the active runway, the pilot will hold short until he is inside his departure window. If there is other traffic inside the HVO AOA, the pilot will notice his sequence number begin to count down as he approaches the active runway. Once he is inside the departure window, and his sequence number is upgraded to #1, he is cleared to taxi onto the active runway and commence his takeoff.

There may be occasions when an HVO aircraft would take-off but desire to stay in the HVO Control Zone near the airport (eg. flying multiple approaches at the airport). In this case, the request to stay in the local area would be a part of the initial message to the AMM, and after takeoff, the HVO aircraft would be issued a new sequence number for his position in the traffic arrival/departure cue. After each approach, the aircraft would again be issued a new sequence number.

Once a departing aircraft is airborne, the pilot flies to his requested DF via a published departure procedure. Compliance with this standard procedure, coupled with his departure window, allows him to remain clear from other departing and arriving traffic. Prior to reaching the DF, he contacts the local ATC sector controller who, because of early coordination from the AMM, is already aware of his impending departure from the HVO AOA and intent to transition into the en-route structure.

Based on the previously coordinated and approved departure window, the ATC controller is aware of the window of time in which the HVO aircraft will reach his requested DF. Once radar contact is established, and the controller is ready to begin providing separation, the HVO pilot requests and receives their IFR clearance, relieving them of self-separation responsibilities.

There will be holding patterns established at each of the departure fixes. If there is an unusual event with respect to sequencing, or leaving the HVO AOA, an HVO equipped pilot will easily enter the holding pattern at his approved fix. They will use their CDTI to ensure no traffic at their selected holding altitude.

2.1.2 En Route Operations

After ATC established control over the aircraft, the en-route portion of the flight begins. In the year 2010, it is assumed that, this IFR portion of the HVO/IFR composite flight plan will be conducted under standard IFR in today's controlled airspace.

Approaching an HVO AOA, the ATC controller will issue descent clearances consistent with the planned arrival. While still outside the zone, the arriving aircraft will transmit a landing clearance request to the AMM at the arrival airport. This message will be the initial contact with the arrival airport's AMM. The AMM will respond by data-link message indicating the pilot's request has been received and communication has been established between the AMM and the arriving aircraft.

The AMM at the arrival airport would have access to the original flight plan data as part of the initial coordination process with ATC. Portions of this initial arrival request message sent to the AMM (outside the HVO AOA) from the requesting arriving aircraft would confirm and update that original flight plan data. This arrival message will also contain, but may not be limited to the pilot's requested IAF, Estimated Time of Arrival (ETA), and information on aircraft performance.

For an HVO equipped aircraft to enter an HVO AOA and participate in HVO operations, the aircraft must have established contact with the AMM, be willing to self-separate from other HVO aircraft inside the HVO AOA and receive permission from ATC to enter the HVO AOA.

There will be holding patterns established at each of the arrival fixes, as well as each of the available IAF's. If there is an unusual event with respect to sequencing, or entering the HVO AOA, an HVO equipped pilot will easily enter the holding pattern at his approved fix.

2.1.3 Descent and Arrival

After the arriving aircraft is inside an HVO AOA, the HVO aircraft will request to be released from ATC control. Once released from ATC control, the pilot is required to self-separate from other HVO aircraft. Pilots will adhere to specified separation criteria defining legal separation of HVO aircraft. Pilots will also follow procedures providing easily anticipated maneuvers among self-separating aircraft within the HVO AOA and "rules of the road" to detect and resolve traffic conflict encounters. The self-separation task will be enabled in IMC by new "HVO" equipment; the location of other HVO traffic will be shown on a Cockpit Display of Traffic Information, or CDTI, in the cockpit of all HVO equipped aircraft. Other aids to the self-separation task include Conflict Detection, Conflict Resolution and Conflict Prevention advisory equipment based on the same data that would drive the CDTI and on the rules and separation criteria in effect.

Based on previously transmitted information and knowledge of the local traffic and weather, the AMM will select and assign a sequence number in the arrival/departure queue for the arriving aircraft. In addition to this sequence number, the module will assign an arrival window for the approved IAF, and transmit this information to the arriving aircraft via data-link. Like the module at the departure airport, the sequence number and arrival window will be calculated based on differentials in aircraft performance, time and distance from the arrival fix, winds, other traffic, as well as wake and turbulence requirements. In addition to aiding the pilot in his self-separation responsibilities, and providing for a smooth flow of traffic, *the receipt of and compliance to a sequence number and arrival window is required* to begin an instrument approach. Displays onboard the HVO aircraft will aid the pilot, by helping him comply with his assigned sequence.

With state of the art displays showing both navigational information, and the relative position of other traffic, the pilot easily flies from the arrival fix to his assigned IAF, avoiding other traffic, and arriving during his approved window. Arriving in this approved window makes the task of self-separation a relatively easy task during this critical phase of flight. After arriving at the IAF, he flies an approved instrument approach to the active runway and lands. Once off the runway, an automated message is data-linked to the arrival airport management module, which closes his flight plan.

In a case where the arriving aircraft was forced to execute a missed approach, the pilot flies the published missed approach procedure to a specified fix contained within the HVO AOA. While holding at this fix, the pilot continues to self-separate. The pilot transmits a message to the airport AMM, requesting a new sequence number and arrival window. Once this message is received and processed, the AMM data-links both the new sequence and arrival window, which restarts arrival sequence.

2.1.4 Mixed-Equipage

Up to this point in the discussion of the concept of operations it has been assumed all aircraft have some minimum equipment allowing these "HVO operations." Additionally, these operations are confined to within specially designated HVO control zones. Within an HVO AOA, HVO equipped aircraft have the ability to self-separate in IMC. This capability is enabled in part because pilots of HVO equipped aircraft have position information on other HVO aircraft in the area. They have the ability to provide separation between themselves and the other HVO aircraft with the use of their specialized equipment. However, not all aircraft flying into non-towered, non-radar airport environments will be equipped for HVO operations by 2010, so the issue of mixed equipage must be addressed.

The primary issue regarding traditionally equipped IFR aircraft operating in an HVO airport environment is the lack of surveillance of these aircraft by ATC and/or other aircraft (HVO and non-HVO), and the necessity of providing separation *assurance* between all aircraft in the airport environment in IMC. Although HVO aircraft will be able to separate themselves from each other, without proper procedures and possibly additional equipment, HVO aircraft will not be able to separate themselves from unequipped aircraft and vice-versa. In today's environment, for IFR operations in IMC at these types of airports, separation assurance is provided through a set of procedures that generally restrict operations to only one aircraft at a time in the airport environment. While this is safe, it is not always very efficient. The HVO concept of operations that allows for multiple aircraft operating the airport area would generally be more efficient than today's system, but is only feasible when all aircraft are either HVO equipped or have a way to "see and avoid" each other as they inter-operate using different procedures.

Therefore, this concept of operations assumes that there will be two different sets of operations that can occur at an airport in IMC– HVO operations or today's procedural separation operations. While the airport can handle either type of operations at any time, these two different methods of separation assurance provision will not occur simultaneously. When there are HVO aircraft operating in the HVO AOA, HVO operations are in effect and traditional IFR operations are not permitted. When procedural separation is in effect, HVO operations are not permitted and all other aircraft must be excluded from the HVO AOA ("sterilization" of the airspace). The type of operation that occurs at the airport is dependent on the service requested by the pilot as the pilot approaches the HVO AOA.

When an aircraft approaches the HVO AOA, the AMM is notified of the aircraft's intent to land or transition the HVO AOA and the type of operation desired. If the aircraft approaching the airport is HVO equipped and desires HVO operations, sequencing commensurate with HVO operations is provided and no traditional IFR operations are allowed. This works if there is one HVO aircraft operating in the HVO AOA or multiple HVO aircraft operating in the HVO AOA. It is essentially the concept of operations described earlier. If, however, a non-HVO equipped aircraft approaches the airport, the pilot notifies ATC of his desire to land at that airport. This information is relayed from the controller to the AMM and the AMM incorporates this request into its departure/arrival queue. Once all HVO aircraft have landed or cleared the zone, the traditionally equipped aircraft is permitted into the HVO AOA. All other aircraft (either traditionally equipped IFR aircraft or HVO aircraft) are kept out of the zone. Once the aircraft has landed and notified ATC, the HVO AOA considered clear and other use requests, either a traditional or HVO operations, can be processed.

2.1.5 Non-Normal Operations

Some examples of non-normal operations might include the following:

- Systems failures, loss of:
  - Communications
  - Navigation
  - Surveillance—Loss of ADS-B, TIS-B signals if used
  - Weather Information
  - Displays—If pilot loses CDTI and longitudinal separation guidance information or display
  - Automation—Automated warning in airport surveillance automation system alerts all aircraft and controller

In the case of any of the above circumstances, procedures and technologies would be in place to allow for a graceful degradation to safely transition to less than HVO allowed levels of operation.

2.1.6 Rare-Normal Operations

Some examples of Rare-Normal Operations are:

- Wind shear
- Pilot errors:
  A pilot/aircraft fails to maintain separation distance and/or violates his Arrival Window during operations. Once again, procedures and technologies would be in place to allow for a graceful degradation to safely transition to other than standard HVO procedures.
-
  For example, if an aircraft were too early for an assigned Arrival Window but continued on their approach, the aircraft on which they were encroaching would be able to see this and take appropriate action if necessary for safety. Similarly, if an aircraft was late for their arrival window yet chose to continue the approach, then the following aircraft, would be responsible for maintaining appropriate separation distance, as right of way rules dictate that the aircraft lower on the approach has priority. However, the aircraft in violation of its clearance window may have to address this incompliance, just as with non-compliance with an ATC clearance in traditional positive control.

Once on published approach, as today, a guidance deviation in excess of full scale requires execution of a missed approach procedure.

Rules of the road would be in place to assure the safety of other than normal operations.

- Controller errors:
  Procedures very much like todays would be in place
- Hazardous weather:
  Hazardous weather (thunderstorms or icing conditions in excess of aircraft certification levels) on the approach profile may require deviations or missed approaches. Hazardous weather graphics are available via data-link to the airplane and could be displayed in the cockpit. Pilot would be responsible for deviations and their compliance with Terminal approach procedure guidelines (TERPS), and for maintaining separation from traffic during deviation.
-

2.2 CONCEPT HVO-B

(This is Va SATSLab Conops HVO1)

Sequencing performed by the controller. Separation maintained using a combination of ADS-B and interrogating traffic detection systems and cockpit display of traffic information (CDTI). For scenarios in which all aircraft are equipped with ADS-B and CDTI, electronic separation responsibility assumed by participating pilots. For mixed equipage scenarios (one or more aircraft not equipped with CDTI, but equipped with at least a Mode-C transponder) those aircraft equipped with ADS-B and CDTI follow in trail of non-equipped aircraft to enable SATS HVO procedures.

Introduction

Overview and Philosophy of Con OPS

Airports that do not have TRACON radar coverage to the surface or control towers will be able to sustain IMC operational rates closer to airports that have these services. Special Authorization Required (SAR) approaches will be approved for aircraft and pilots that meet the equipage, training and maintenance requirements and fly the procedures specified in the SAR documents. Achieve HVO goals through station keeping, that is, maintaining separation in trail, using a traffic display in the cockpit (CDTI). Information displayed on the CDTI is used to determine distance from aircraft in the Airport Operations Area (AOA). Non-SATS equipped aircraft will be detected using a small terminal sensor, thus maximizing the opportunity to for HVO SAR operations. Decision aids may be provided to the pilot to increase accuracy (and subsequently safety). Aircraft that are not equipped with SATS will not be allowed to follow in trail of any other aircraft and will be allowed to enter the AOA under the same rules as today.

The following conditions may apply:

- VFR traffic will be operating concurrently with IFR traffic in VMC conditions, and all pilots would have see-and-avoid responsibilities when in VMC, as they are currently.
- Sequencing will generally be done according to timing of arrival in the terminal area. All sequencing is by a controller; with the pilot responsible for separation only.
- Only one Standard IFR airplane, the lead airplane, can be in the high volume operations airport operations area (HVO AOA). Non-equipped airplanes are not cleared for the approach until all preceding airplanes on the ground (same as currently). Multiple SATS aircraft can follow behind one standard IFR airplane.
- Self-separation is permitted where airplanes are cleared to IAFs on different legs of the T, provided one airplane is cleared to the IAF at 1000 ft over intermediate and final approach legs and can descend to the published minimum only after reaching the intermediate leg. This will be for Ts that are longer than the standard 15 miles total.
- If second pilot can see first airplane electronically, and he accepts separation responsibility, second pilot can be cleared to IAF with a non-equipped airplane ahead of him.

Definition of Terms

Changes from Current ConOps, Procedures, or Policies

Changes in Air Traffic Procedures

Controllers and pilots agree to transfer limited separation authority to pilots in the terminal area where special arrival and departure procedures have been established. To employ these procedures, pilots and their aircraft must meet specified requirements regarding training and equipment. This limited transfer of separation authority is similar to pilots accepting responsibility for separation on visual approaches under IFR. In this case, pilots would be authorized to maintain specified in-trail separation behind an aircraft sequenced and initially separated by the controller.

AOC would no longer be obliged to call out the number and location of VFR traffic in the AOA for arrivals when pilots are on electronic visual approaches. The automation would have to provide this service via communication by TIS-B to the pilots in the AOA.

	Controller Roles	Pilot Roles
Target System Performance Level: 5 airplanes in terminal area, 15 ops/hr. ConOps: airborne and ground systems, mixed and SATS-only airport ops modes	Sequencing performed by the controller, including on missed approach.	Non-equipped airplanes remain under current IFR procedures. Equipped airplanes, station keeping via CDTI from either ADS-B, TIS-B, or TCAS. Separation maintained using a combination of ADS-B for direct air-to-air position and intent data, and from a small terminal sensor, fusion and tracking system, and traffic information service broadcast (TIS-B), with CDTI. For scenarios in which all aircraft are equipped with a ADS-B and CDTI, electronic separation responsibility is assumed by participating pilots. For mixed equipage scenarios (one or more aircraft not equipped with CDTI) those aircraft equipped with CDTI follow in trail of non-equipped aircraft.

Changes in Flight Operations Procedures
Pilots could perform these special arrivals and departures if they met requirements specified in special authorization documents, similar to Part 91 Appendix A, which provides the requirements for Category II approaches.

Air Traffic Services

Flight Planning

Pilot would be required to indicate on the flight plan that he and his aircraft are SATS-SAR-HVO capable according to the published requirements.

ATC Separation

As described above, controllers would transfer separation authority to pilots by agreement of both the pilot and controller as to the airplane directly ahead of the agreeing pilot's airplane, in a manner similar to a pilot accepting separation responsibility from the airplane ahead of him today in visual conditions in the terminal area.

Advisory

Weather

Weather information would be updated by automated digital uplink to a cockpit MFD.

Traffic

A combination of ADS-B and TIS-B, plus CDTI for situational awareness and automation for decision aiding would enable the pilot to be aware of aircraft with transponders or ADS-B transmitters. Controllers continue to provide pilots with information on other aircraft in the terminal area before clearing them for the approach.

Synchronization

Airborne Traffic

Controllers would set up initial sequencing at seven mile intervals to an IAF or metering fix, based on first-come-first-served.

Ground Traffic

Ground traffic on the airport surface function in the same way as the baseline. However, aircraft cannot take position on the active runway for an instrument departure unless they are within the time window for which they have been awarded a departure clearance.

Navigation

Navigation would be provided by the GPS WAAS system, with avionics compliant with TSO C145 and C146, in compliance with RTCA/DO-229C.

Airspace Management

Airspace changes would have to be made to provide additional IAFs to GPS WAAS approaches where necessary to have at least one in radar coverage.

Airport Management

No change to baseline. However, airports would be responsible for providing official time synchronized with ATC that is available to pilots through the filing procedure, and via ATIS information prior to taxi.

Certification Services

Aircraft Certification

New policy on SATS-SAR avionics may be necessary.

Flight Standards

New policy on pilot training will be necessary.

Key Assumptions

- All separation and sequencing services provided by a TRACON or ARTCC with low altitude radar coverage will be provided by SATS sufficient to handle subject performance level with no, or virtually no, controller involvement to avoid increasing FAA costs.
- Mixed-equipage must be permitted, without denying access to current VFR or IFR aircraft or pilots.
- Assume airport and terminal area is within one ATC sector for handoff to SATSLab automation from same controller.
- All aircraft prior to and within airport operations area (AOA) would be on the same voice frequency, either with ATC or a synthesized voice or CTAF frequency.
- Assume maximum approach and departure speed differential of 40 knots.
- The following procedures only apply when all IFR aircraft in the terminal area domain are SATS-SAR Aircraft:
- Aircraft have the Baseline Architecture Airborne Equipment, including with ADS-B, CDTI and related automation for station keeping as provided in the SATS-SAR document.
- They are flying the published SATS-SAR-HVO procedure, and are otherwise in compliance with the SATS-SAR-HVO for this procedure (e.g., training, maintenance).

Functional Architecture

Descriptions of the functions allocated to major components are described in detail in sections 1 and 3 and therefore a functional architecture will not be provided for this ConOps.

ConOps. There are two technology variations to this ConOps, 1) ground based sensors and TIS-B, with Cockpit Display of Traffic Information (CDTI); and 2) active traffic detection and resolution (TCAS like) on the airborne side with no ground sensor augmentation necessary.

The remainder of the ConOps is basically the same, pilot is responsible for separation with the help of varying levels of automation. Mixed equipage is addressed through procedures and automation.

Proposed Air Traffic and Flight Operations Event Sequences

Air Operations

Arrivals

Normal Operations

- Arriving IFR traffic initially are under surveillance and control of either an ARTCC or a TRACON with another airport as primary airport, using conventional en route or terminal radar surveillance systems.
- This ATC facility sets initial sequencing separation to meet requirements; ATC provides vectors to the pilot to an initial approach fix (IAF) (with a time window to cross it) and a clearance to make the approach. Controller sets this sequencing based on airplane speed and

distance from an IAF, and where ETA at an IAF similar, with conventional IFR aircraft leading and the SATS aircraft following.

- The controller asks the following SATS pilot to accept "electronic visual separation" during the entire approach based on internal aircraft display systems and automation to maintain spacing, and then allocates the separation function (responsibility) to the airplane/pilot unit as soon as the aircraft crosses the IAF.
- Pilot of SATSLab aircraft then uses aircraft displays and automation to maintain separation distance, i.e., station keep behind the traffic in front of them.
- Pilots flies the published approach procedure, including landing.
- If a SATS aircraft will be followed by a conventional IFR, then either the controller must be able to handle the separation responsibility on a time available basis, or not issue the approach clearance to the conventional IFR aircraft until the SATS aircraft has concluded the approach.
- The pilotmay requests "electronic separation" for the approach from the controller when he calls the controller who will clear him for the approach, or the controller may request if the pilot will accept an HVO approach. The pilot and controller must both agree before the HVO procedure can be initiated (similar to a visual approach).
- Based on the pilot acceptance and the flight strip equipment suffix indicating the pilot and aircraft are SATS-HVO-SAR capable, the controller clears the pilot for an electronic separation, HVO, approach.
- Controller informs pilot of all traffic known by controller to be in the AOA and approximate location, which may be "one aircraft cleared into AOA 10 minutes ago, another was cleared 5 minutes).
- The Controller sets initial sequencing based on first to arrive in the terminal area, the same as currently.
- The Controller holds aircraft, as necessary, to provide separation at the IAFs that meets current terminal separation requirements. Airplanes are cleared to the approach not less than 7 miles apart.
- ATC provides vectors to the pilots to an initial approach fix (IAF) with a time window to cross it and a clearance to make the approach. Controller sets this sequencing based on airplane speed and distance from an IAF, and airplane wake turbulence requirements, as currently provided.
- The controller may clear arriving airplanes to any of the three IAFs in the Standard T approach. "N 1234, x miles from ABCDF, proceed direct to ABCDF (one of the IAFs), descent and maintain or maintain or cross at xxxx thousand, cleared for the HVO-LLM RWY 32 approach ." HVO STAR page, and LLM IAP page.
- When airplanes are cleared to an opposite direction IAF when any other aircraft are still anywhere on the approach, one aircraft will be assigned 1000 feet over the other, and they may not descend until they are on the intermediate leg.
- Controller then allocates the separation function (i.e., responsibility) to the pilot as soon as the aircraft crosses a metering fix, which is in radar coverage. Note: can't use procedural separation because they don't get flight strips, and only apply procedural separation one aircraft at a time in the AOA. Controller advises pilot of traffic in terminal area, terminates radar services, and provides an "electronic separation" clearance to the pilot.

- All pilots fly the published approach procedure, to a landing, IFR cancellation, or a missed approach.
- Pilots are required to maintain a minimum of separation distance (or possibly time) based on CDTI display and automation.
- Pilot immediately informs controller of landing or missed approach using RCO.
- SATS Pilot monitors CTAF, if preceding pilot (SATS or standard) has not announced landing or cancellation or missed approach, following pilot must execute a missed approach at FAF. Pilots may remind leading aircraft pilot to cancel or announce landing when he sees the landing.
- All pilots must transmit and receive on CTAF, IAF (including intersection) and FAF are mandatory reporting points.
- If a SATS aircraft will be followed by a standard IFR, then the controller must not issue the approach clearance to the conventional IFR aircraft until the SATSLab aircraft has concluded the approach, to a landing or cancelled IFR, or missed and radar contact re-established.
- On missed Approach, pilot calls controller and notifies of missed approach.
- Procedural separation is maintained based on flying missed approach procedure to a missed approach holding point away from approaching aircraft or until radar contact is re-established.
- Then pilot may request clearance back to an IAF or alternate destination.
- Controller sequences aircraft to IAF based on other traffic or clears to alternate.

Rare Normal Operations

Adverse Weather

Same as current. Pilots should provide PIREPs on CTAF, to partially replace lack of controller seeing weather.

Traffic in excess of capacity

N/C

Pilot Errors

Pilot fails to maintain separation because of either aircraft performance limitation or pilot understanding. Following pilot is responsible for separation, and must execute a miss when separation distance is not maintained below critical limit (3 miles). 7 miles at IAF, compression results in 5, to be maintained, miss if below 3. If following aircraft is fuel critical, he declares an emergency SAB(?), lead airplane executes a miss if directed by controller.

Controller Errors

Separation at IAF less than 7 miles. Pilot has to maintain 5 miles separation and execute a missed approach at 3 miles.

Abnormal Operations

Abnormal Operations are those leading or potentially leading to clearance nonconformance or other unsafe situations.

Systems failures

Loss of Communications

Loss of surveillance information broadcast transmitter is the equivalent of total loss of surveillance. See below.

Loss of airplane communications, N//C; other pilot's conformance is relied upon for safety (low probability of both aircraft with simultaneous communications failure justifies this).

Loss of Navigation

N/C

Loss of Surveillance

When lose both secondary and primary radar, revert to procedural separation, with new procedures for this type of operation. Pilot misses approach, contacts last controller. Missed approach procedure that will result in positive separation, to a missed approach holding fix, and altitude based on sequence from landing, i.e., first aircraft holds at 3,000, second at 4,000 etc.

Loss of Weather Information

N/C

Loss of Displays

If any SAR systems fails in the en route domain, do not initiate a SATS SAR approach.

If any SAR system fails on the approach, fly the missed approach procedure: fly to missed approach holding point (MAHP) at altitude that puts pilot in radar coverage. No impact on conventional IFR.

Loss of Automation

Same as displays if required. I.e., if decision aiding is not required, and it fails, can continue; it if is required, must miss. No impact on conventional IFR.

Deliberate Pilot Misuse

Shortcut to runway, not following IAP or STAR. Training.

Security Emergency

4-D flight plan, note all IFR flight plans are 4-D prediction, host turns it into 4-D, maintains track including wind, updates strips, as long as in radar coverage, that is why must advise ATC of speed change of more than 10 knots or more than 3 minutes off of predicted time arrival at a fix. 4-D is a commitment, based on FMS to meet a flight plan. ATC has conformance monitoring now.

Departures

Normal Operations

- Controller only allows high volume operations when airport ceiling or visibility is below a set level, if all aircraft are equipped to electronically avoid runway conflicts.

- If all aircraft are so equipped, controller may clear aircraft to takeoff based on electronic see and avoid rules.
- Once so cleared, pilots departing are responsible for confirming another aircraft is not on final approach within 7 miles of the runway, before they take the runway, and must then begin their takeoff roll within 30 seconds of taking position on the active runway.
- If departing aircraft is unable to begin takeoff roll within 30 seconds of taking position, it must taxi off the runway immediately and announce this on the CTAF.

Rare Normal Operations

Adverse Weather

Same as for arrivals.

Traffic in excess of capacity

When conventional IFR aircraft is cleared into terminal airspace, ATC rescinds departure clearances until that aircraft has landed and flight plan closed. Conversely, when conventional IFR aircraft is cleared for takeoff, ATC holds all other aircraft outside terminal airspace until radar contact is established with conventional IFR on departure. Capacity excesses are less significant than clearance for one or more aircraft. Alternatively, ATC adjusts (increases) time window for departure to decrease flow rate. Pilots monitor CDTI for proper interval prior to takeoff roll.

Pilot Errors

Same as for arrivals.

Controller Errors

Pilots monitor departures and arrivals for interval based information displayed on CDTI. If interval is not sufficient at any time prior to the expiration of departure clearance window, pilot must return to ramp and obtain new departure clearance.

Abnormal Operations

System Failures

System failures prior to takeoff roll that are essential to flight require cancellation of flight clearance and reporting to ATC. Following system failures assume that they occur at some point past takeoff refusal speed.

Loss of Communications

Applicable to both SAR equipped and conventional IFR: If VMC, return to departure airport and land as soon as practicable. If IMC, fly departure profile as assigned and comply with lost communications procedures per baseline.

Loss of Navigation

Applicable to both SAR equipped and conventional IFR: If VMC, return to departure airport and land as soon as practicable. If IMC, climb to altitude assigned and attempt to contact ATC and request vectors to nearest suitable field with services consistent with navigation limitations.

Loss of Surveillance

If VMC, return to departure airport and land as soon as practicable. If IMC, the aircraft then becomes equivalent to a "Standard IFR" aircraft. Conventional rules

Loss of Weather information

Loss of weather displays is at pilot's discretion to continue based on forecast weather. No action required by ATC. No change or impact to conventional IFR.

Loss of Flight Information

For SAR equipped aircraft only:

- Loss of vacuum instruments, or PFD, ND, HITS, SPI. Partial panel, request "no-gyro approach" at point of origin consistent with Order 7110.65, sec. 5-10-3.
- Loss of MFD, moving map. Revert to raw data, VOR CDI.
- Continuation of flight is at pilot's discretion.

For conventional IFR aircraft: No impact.

Loss of Automation

SAR equipped: Departure procedure should not require coupled automation. Proceed per clearance. Re-consider destination based on forecast weather and limitations of automation. Elect to continue or request clearance to an alternate with better weather or approach procedures compatible with degraded system.

Conventional IFR: No impact.

Deliberate Pilot Misuse

Pilot training and AIM guidance on the hazards of misuse.

Controller monitors departure corridors for compliance with separation standards and route adherence.

Security Emergency

Phantom controller communications through use of VHF radio, when controller can't hear transmission. Pilot monitors for aberrant commands.

Ground Operations

Arrivals

Normal Operations

- Controller only allows high volume operations when airport ceiling or visibility is below a set level, if all aircraft operating in the air and on the ground at the airport are equipped to electronically avoid runway conflicts, i.e., SATS Baseline Airborne Architecture.

- If all aircraft are so equipped, controller may clear aircraft to land based on electronic see and avoid rules.
- Once so cleared, pilots arriving are responsible for confirming another aircraft is not on the runway.
- If another aircraft is still on the runway when the pilot is on a three mile final (distance negotiable by research), pilot executes missed approach. If any other ADS-B equipped vehicle, or vehicle located by the STS or IR sensor and position data linked up by TIS-B, pilot executes missed approach.

Rare Normal Operations

(All procedures are applicable to both SAR and conventional IFR aircraft.)

Adverse Weather

If safe landing cannot be made or completed (excessive crosswind, runway environment not in sight at DA), execute missed approach procedure.

Traffic in excess of capacity

- If another aircraft is on the runway, execute missed approach and enter VFR downwind if weather permits.
- If another aircraft is on the runway, and weather is below minimums for closed VFR traffic, execute IFR missed approach procedure.

Pilot Errors

For incorrect landing technique, or insufficient time and distance to adjust to runway environment, execute missed approach procedure.

Controller Errors

Departing pilots "clear" arrival airspace visually, and announce departure before taking runway in the event another aircraft was inadvertently cleared to land.

Abnormal Operations

(All procedures are applicable to both SAR and conventional IFR aircraft.)

System Failures:

Communications failure is the only system malfunction requiring action different from "normal" operations on the ground.

Loss of Communications,

Clear runway as soon as possible and comply with published ground taxi procedures. Upon shutdown, contact ATC and report landing and flight plan closeout.

Deliberate Pilot Misuse

- VA SATS Lab, 2002 Pilot training and AIM guidance on the hazards of misuse. Other pilots and airport staff monitor ground operations for inconsistency with local course rules.

Security Emergency Pilot monitors for aberrant commands. Airport manager and other airport observes monitor for abnormal behavior, taxi procedures, and taxi speeds.

Ground Operations

Departures

Normal Operations

- Controller only allows high volume operations when airport ceiling or visibility is below a set level, if all aircraft are equipped to electronically avoid runway conflicts.
- If all aircraft are so equipped, controller may clear aircraft toland or to takeoff based on electronic see and avoid rules.
- Once so cleared, pilots departing are responsible for confirming another aircraft is not on the runway or a three mile final.
-

Rare Normal Operations

Adverse Weather Adverse local weather may preclude departure within time window authorized. Pilot then returns to parking ramp to obtain new clearance window.

Traffic in excess of capacity Ground traffic is separated via "see and avoid" visual techniques on the airport surface. Departing traffic are de-conflicted with arrivals based on capacity limits established by ATC. Pilots monitor CDTI for established traffic volume limitations.

Pilot Errors If pilot take runway without sufficient interval, pilot on final approach should view situation on TIS-B/TCAS. Offending pilot should clear runway or missed approach will be required.

Controller Errors Departing pilots "clear" arrival airspace both visually and with CDTI, and announce departure before taking runway. These procedures should serve as check and balance against controller management within airspace volume

Abnormal Operations

System Failures: Completion of ground checklists preclude departure with system failures. In the event that a failure occurs on takeoff roll (above refusal speed) proceed with procedures appropriate to the aircraft. See "Abnormal Operations" procedures under Air Operations.

Deliberate Pilot Misuse Pilot training and AIM guidance on the hazards of misuse. Other pilots and airport staff monitor ground operations for inconsistency with local course rules.

Security Emergency Pilot monitors for aberrant commands. Airport manager and other airport observes monitor for abnormal behavior, taxi procedures, and taxi speeds.

2.3 *CONCEPT HVO-C*

(This is Maryland Mid-Atlantic SATSLab Conops)

Description of concept of operations by phase of operation

2.3.1 Departure

In preparation for departure, the pilot of the SATS aircraft will file a VFR/SATS or IFR/SATS flight plan. It will be possible to prepare and file the flight plan from home or at the airport over the internet, or from the aircraft via data link (this may be accomplished in several ways: via SATS aircraft acting as an aviation internet node; via data link communication interface to a land line server at the airport; or via a cell phone or satellite connection available in the cockpit). The flight plan will be identical to today's flight plans with the minor exception of explicitly noting the vehicle as a SATS aircraft with notation of particular avionics such as visibility enhancements or ADS-B. Upon ATC approval of the flight plan, ATC will assign an estimated departure time based on other flight plans approved for that airport. This in essence establishes a departure sequence for all aircraft. The airspace need not be sterile of non-SATS aircraft, since airborne enabling sensors on the SATS aircraft will have capability to maintain safe separation from non-SATS aircraft, in IMC, during sequence to the departure fix (how mixed aircraft operations are managed is discussed on paragraph 3.d). SATS aircraft will automatically exchange their approved flight plan information with one another prior to departure. This will include arriving SATS aircraft, since arriving and departing aircraft will be operating on the same runways.

As the departing SATS aircraft taxi to the active runway, the multi-function display will show the position and sequence of other taxiing SATS traffic, as well as SATS aircraft on final or missed approach. The on-board SATS computer will display the airfield taxiway and runway layout from is database and overlay this image with traffic positions. When the runway is active with an SATS aircraft on final or departing, the runway image will be displayed as "hot" by such means as a color change. This will provide the pilots with situational awareness of their location during IMC and poor visibility and mitigate the potential for runway incursions. In addition, enhanced vision sensors on the SATS aircraft will enable the pilot to have much improved situational awareness of the airport operating areas and traffic locations. Voice communication is encouraged with all vehicles on the airfield, departing and arriving, in order to account for non-SATS aircraft. Most likely, the airport will not be within range of ATC voice communication until after departure and nearing the departure fix. Local airfield information and other information needed by the pilot prior to takeoff will be made available through locally linked information centers that maintain national communications. The departure sequence number for each SATS aircraft will decrement as the prior SATS aircraft either departs or closes the flight plan prior to departure. When the SATS aircraft is number 1 for departure at its ATC assigned departure time and the runway is clear of traffic, the pilot will initiate ground role and takeoff. *It is imperative that the SATS aircraft not depart prior to the assigned departure time regardless of the being number one in the sequence* (see paragraph 3.d for mixed equipage operation). The takeoff time will be automatically reported to ATC via data link if a communication link is available. Otherwise, the flight plan will be updated at the first opportunity. If data link serve is not available, the SATS aircraft computer will remind the pilot to update the flight plan via voice radio communication.

Once airborne, the departing SATS aircraft is flown to the assigned departure fix via a dynamic departure procedure. Navigation via GPS WAAS is expected to provide the necessary accuracy, reliability, and availability of service. Prior to arriving at the departure fix, the pilot contacts the local ATC sector controller with an automatically prepared text message containing the estimated time of arrival at the departure fix. ATC will establish radar contact and provide instructions to hold at an assigned altitude, proceed as filed, or proceed with an amended flight plan route. Other SATS aircraft in trail to the same departure fix will monitor their positions and maintain separation. As they enter radar control coverage, they will contact ATC who is anticipating their arrival and will in turn, provide instructions and separation. On-board SATS aircraft software will provide insertion guidance into either the holding pattern or alternate departure routing and guidance upon exiting this common transition fix between SATS and ATC control.

2.3.2 En Route

SATS aircraft will conform to IFR procedures as in today's en route airspace environment. It is expected, however, that free flight will be more common, particularly since there may be few established airways between the many public-use airports in the NAS. Navigation via GPS WAAS is expected to provide to necessary accuracy, reliability, and availability of service. For short, more local flights, approximating 150nm or less, it may be possible to maintain SATS ownership for routing, sequencing and separation without the need for positive ATC control. ATC will likely monitor events for these short flights exercising communications by exception.

While en route and traversing other general aviation airports with data link connectivity to the NAS-wide Information System (NIS), SATS aircraft will have the capability to send and receive updated flight plans, FIS, TIS and CIS information for destination and alternate airports. The NIS will be better able to calculate traffic flow projections and dynamic traffic density for sectors and TRACONs by having up-to-date traffic positions and flight plans of SATS aircraft via these general aviation airport digital interfaces to the NIS.

In addition, an advanced processor and network system on the SATS aircraft will blend all static and dynamic information pertaining to aircraft system's health and status, the surrounding environment and destination/divert airfields. Knowledge-based intelligent processing will be performed by a special computer to oversee ATC instructions and pilot conformance to flight path and flight plan, as well as collaborate directly with ATC and other SATS aircraft via digital data link. This system will provide predictive assistance by anticipating normal pilot functions and evaluating and displaying appropriate information to the pilot.

Upon approaching the final en route leg to destination airport, the ATC controller will issue descent and approach clearances consistent with the planned arrival. ATC will assign estimated approach times to SATS aircraft flight plans, which will function as the approach sequence for all SATS aircraft. The SATS aircraft will automatically exchange this information for the purpose of self-separation and self-sequencing for the approach and landing. The SATS aircraft will also receive updated TIS, FIS, and weather information from the airport's digital communication interface to the NIS if available. Otherwise, that information will be available via cellular or satellite data link services, or alternatively, via the airborne internet where each SATS aircraft functions as a communication node.

As the SATS aircraft arrives at an established arrival fix, ATC will either clear the aircraft for descent and approach or assign a holding pattern and altitude.

2.3.3 Descent and Arrival

Once released by ATC (after ATC determines that its picture of airport area traffic matches that of the SATS aircraft), the SATS aircraft will be responsible for maintaining self-separation and self-sequencing for the approach and landing. This capability is enabled by on-board computer functionality of a special knowledge-based processor. Situation awareness of all transponding traffic is shown on a multifunction display. Conflict detection of Mode-C traffic and terrain will be the provided by additional sensors on the SATS aircraft. Conflict resolution for traffic, terrain and weather will be provided by the on-board computer. The SATS aircraft will also be capable of providing guidance for approved alternative approach procedures to the assigned runway, such as circular approach, curved approach, offset approach, non-standard glide paths, etc. Navigation via GPS WAAS or LAAS is expected to provide the necessary accuracy, reliability, and availability of service. In preparation for the approach and landing, the on-board SATS computer will display the approach plate and airport diagram on the multifunction display. The pilot will be flying a form of "highway in the sky" that contains current and predictive flight path/angle of bank/climb/descent paths. It will also anticipate the pilot's needs for a checklist and display the prioritized list. If not all items on the checklist are acted upon, the computer will alert the pilot. Certain checklist items will be performed automatically to reduce workload.

While descending to the initial approach fix (IAF), all SATS aircraft are communicating their positions with one another. In addition, they will also provide information on their fuel status, flight performance, and system health. This information, together with their positions, is essential for maintaining self-sequence. An aircraft with severely low fuel may be given a higher priority for landing. This logic is resident in all SATS aircraft computers for collaboration and decision making. Any SATS aircraft unable to maintain self-separation within adequate margins while self-sequencing will automatically instruct the pilot to proceed to a predefined fix and re-enter the arrival sequence with a newly established sequence number. When this occurs, all SATS aircraft are notified and collaboration among them updates the arrival sequence. Re-entry guidance is assisted the SATS aircraft computer.

From the IAF, the SATS aircraft will proceed to the final approach fix (FAF) and continue on to land if the ceiling and visibility are within the published criteria. Otherwise, SATS aircraft will execute a missed approach to a predefined fix and holding altitude. Immediate data link notification to the other SATS aircraft will permit collaboration for establishing actions for other SATS aircraft, such as holding patterns, re-established approach sequence when visibility improves, or self-sequencing to a departure fix for flight to an alternate airport. (A missed approach due to weather being lower than allowed for the approach procedure is expected to be a low probability of occurrence since the actual weather conditions can be determined for the destination airport with enough advance notice to proceed instead to the alternate).

Also while on final approach, the SATS aircraft will receive positions of SATS aircraft on the airfield. If a SATS aircraft encroaches on the active runway, a warning on the landing aircraft's primary guidance display will alert the pilot, and the on-board computer will automatically display missed approach guidance instructions. Enhance vision sensors on the SATS aircraft will further enable the pilot to "visually" acquire the runway, as well as obstacles on the runway not otherwise detectable.

Upon landing and clearing the runway, the SATS aircraft will data link closure of its flight plan via cellular or satellite communication, or via the digital airport link with the NIS if available.

2.3.4 Mixed Equipage Operations

It is unrealistic to expect ATC to manage SATS aircraft as groups and receiving preferential treatment. For the most part, all aircraft filing flight plans receive departure times on a first-come basis. Since it is likely that SATS and Mode-C transponding aircraft will be mixed during both IFR arrival and departure, enabling technology should accommodate these situations, rather than imposing preferential rules and procedures upon ATC to create sterile "SATS-only airspace." ATC management of non-SATS aircraft by exception could create complicated traffic flow and holding-pattern problems, as well as have detrimental affects on non-SATS aircraft.

Even though SATS aircraft will have decrementing sequence numbers for departure, these numbers do not take precedence over their ATC assigned departure time. Non-SATS aircraft may have departure times intermixed with SATS aircraft. For example, at 0645, a SATS aircraft with a departure sequence number of 1 and an assigned departure time of 0700, should not taxi to the number 1 position for takeoff, since a non-SATS aircraft may have the 0645 departure slot or and estimated landing time. Furthermore, the 0700 assigned departure time is based on the ATC service provider's knowledge of en route traffic and their time-dependent plan to insert the aircraft into en route traffic flow based on the estimated time of arrival at the departure fix. Too early or late arrival at the departure fix could affect ATC's management of traffic flow or result in the aircraft holding at the departure fix. Adherence to ATC assigned times is of top priority in this ConOps.

All aircraft operating in IFR-on-top will be transponding either Mode-S or Mode-C. Mode-C aircraft will be detected by SATS aircraft on-board sensors that identify the general bearing, range and altitude of the target. By continuously resolving the velocity vectors, the SATS aircraft will have the capability to resolve Mode-C transponding aircraft positions with sufficient accuracy to maintain separation in altitude, distance, and bearing. However, Mode-C aircraft will not be able to see or separate themselves from SATS aircrafts. Therefore, separation algorithms in the SATS aircraft computer will calculate and display larger separation assurance areas for Mode-C aircraft. These areas may vary in volume over time depending on the geometric relationship of the Mode-C and SATS aircraft. Collaborated results of detected Mode-C aircraft by multiple SATS aircraft via data link may improve resolution of position information which can be shared by all SATS aircraft in the airport's airspace.

While conducting an approach that transitions from IFR to VFR with the airport in VMC, all aircraft must obey see-and-avoid procedures. However, all SATS aircraft will continue to broadcast their identification and position vectors. The SATS aircraft computer system will continue to monitor self-separation with all objects (aircraft, terrain, airspace boundaries, weather, etc.) and conformance with spacing for self-sequencing.

2.3.5 Non-Normal Operations

SATS aircraft will conform to standard flight rules and procedures for in-flight emergencies and CNS avionics failures. For all in-flight emergencies, the SATS aircraft will set its transponder code to the proper frequency.

During approach and departure operations, direct assistance by ATC will not be possible at non-towered, non-radar airports. If communication functionality fails except voice radio communications, then the failed SATS aircraft will radio the other SATS aircraft. They will give priority to landing to the failed-aircraft and collaborate for new sequence assignments. If communication functionality fails except for data link communication, the failed-aircraft will contact the other SATS aircraft. Priority will be given as previously described. If surveillance functionality fails, the failed-SATS aircraft will not be able to maintain separation and self-sequencing. The failed aircraft will notify the other SATS aircraft of the failure, and the other SATS aircraft will give priority to the failed aircraft for landing. If navigation functionality fails, the failed aircraft will notify the other SATS aircraft who will give priority to the failed aircraft to either land (if visibility permits), or to depart the airspace using a backup navigation system to a pre-assigned bearing and altitude that will take the failed aircraft into controlled airspace for ATC or AFSS vectoring to a VMC airport.

The on-board SATS computer will monitor dynamic and static aircraft systems to continuously assess aircraft health parameters. With predictive algorithms, some aircraft system failures can be averted through timely maintenance actions or by modifying the use of aircraft systems while in-flight. The potential for encountering in-flight emergencies due to system failures may be significantly reduced in this manner.

2.3.6 Rare-Normal Operations

SATS aircraft will have data link access to digital weather forecasts. In addition, SATS aircraft will collect weather sensor data in flight, and distribute the data to the NWS. Sensors on the SATS aircraft will also observe lightning strike incidents in localized severe weather cells that may not be observable by ATC. Convective weather at the airport may be detected by local AWOS and reported to NWS to create weather composites. By receiving advance weather information directly from the airport before being cleared for the approach, a missed approach due to adverse weather may be averted, and more efficiently permit ATC to direct all aircraft to their respective alternate airports.

During VMC, the pilot will be required to have situational awareness through see-and-avoid flight rules. SATS aircraft enhanced vision sensors will improve the pilot's ability to locate non-transponding aircraft when operating in non-radar airport airspace.

The on-board SATS computers will monitor pilot flight performance in regard to conformance to flight path and altitude, separation from system identified obstructions (including airspace boundaries and other traffic and weather). Checklists will automatically be generated by the SATS computer in anticipation of flight plan maneuvers. Certain actions will be performed by the computer to relieve cockpit workload, such as checking weather conditions at the destination airport, and identify other alternate airports with acceptable minimums and modify flight plan for review and submission by the pilot. Another example may include automatically locating and displaying the correct approach plate and displaying a flight path from the present position to the IAF. These capabilities will serve to assess flight path conformance, anticipate next step actions, perform redundant duties, and thereby, reduce the potential for pilot induced errors.

2.4 CONCEPT HVO-D

(This is Southeast SATSLab Conops)

INTRODUCTION

Overview and general philosophy of the CONOPS

Hypothesis: VFR airport throughput capacity can be safely increased by a factor of 2-10 through implementation of airborne and ground based avionics and CNS/ATM technologies, coupled with improved flight operations procedures, under CAT I IMC conditions.

Initial experiment activities will include examining simple procedural modifications to today's FAA regulations for flight operations at uncontrolled airports under instrument meteorological conditions. With the ability to provide to both pilots and controllers precise knowledge of the positions of all aircraft in the terminal area of small non-towered airports, it should be safely feasible to increase the airport Instrument Flight Rules (IFR) throughput at much less expense than would be required by the installation of an ILS. With the addition of collaborative sequencing (CSEQ) and conflict detection and resolution (CD&R) capabilities, Dynamic Terminal Procedures (DTerPs) that take into account local weather, traffic, airspace and noise restrictions, and other innovative technologies that could obsolete current approaches to landing lighting systems, we expect to be able to reach the target and perhaps the stretch goal.

The HVO project will consist of a series of analyses, simulations, experiments and demonstrations that show how enabling technologies and innovative procedures can improve on small airport capacity.

We plan to develop, simulate, and fly the following kinds of terminal area instrument procedures under simulated IMC to increase small airport capacity: These procedures depend on accurate, reliable location knowledge of the aircraft, approach thresholds, runway touchdown points, runway exit paths, and aircraft sequencing, for maintenance of operational safety. Aircraft sequencing will be established by "time-stamping" an aircraft into the terminal coverage area as the flight becomes active in the area. All flight experiments and demonstrations will be simulated prior to flight, and safety pilots will be utilized for all flights conducting experimental procedures in simulated IMC. These operations will generally not involve FAA ATC. The procedures available for a specific airport are airport and terminal area airspace configuration dependent, so that the capacity improvement that can be afforded to a specific runway will vary among airports.

In-Trail Operations

We plan to explore collaboratively sequenced in-trail terminal operations at currently VFR airports. Initial operations will include use of obstacle-free fixed approach paths (TerPs), "electronic see and avoid" self-separation advisories and procedures for traffic deconfliction that take advantage of ADS-B position reports from aircraft, ground segment assignment of sequence and processing of in-trail separation distances. We will initially simulate conflicting aircraft to determine the effectiveness of the algorithms and pilot responses. After these trials have proven to be successful, we plan to explore multi-aircraft experiments.

Experiment flight aircraft will be identified and time-stamped as they enter the terminal coverage area. Pilots requesting approach will be assigned, via datalink, an aircraft to follow, or sequence number, and an approach path, with instructions to maintain separation from the previous aircraft in the sequence. Separation criteria will be established for various capacity levels, and aircraft that are unable to maintain the required in-trail separation will be advised to execute a missed approach and return to the queue. We plan to progress from this simplistic approach toward an airborne, object-oriented, 4D flight trajectory sequencing system if early experiments indicate that such a system is warranted for the projected demand at any candidate airport, or to meet the program stretch goal.

Required Time of Arrival Operations

We plan to explore required time of arrival (RTA) terminal operations at currently VFR airports. Initial operations will include ground segment assignment of RTA windows to maintain safe separation distances. Experiment flight aircraft will be identified and time-stamped by the ground system as they enter the terminal coverage area. Pilots requesting approach will be assigned an RTA window via datalink that consists of an arrival fix, a clearance timespan, and an approach path, with instructions to maintain separation from other aircraft in the terminal area. If a subject pilot misses the RTA window, (s)he will be advised via datalink message to execute a missed approach and return to the queue. We plan to start with a single RTA window and assign time spans. As we gain experience in this type of procedure, we will increase the number of RTA windows/approach paths. Once this concept has been proven to be feasible, we plan to explore Dynamic TerPs, based upon local weather, traffic, aircraft capability and pilot preference, and airborne algorithms that will exploit ADS-B capabilities to establish sequencing and self separation among the aircraft. Initially, these DTerPs will be dynamically assigned fixed approach corridors, and as we learn from these initial experiments, we plan to implement adaptive approach corridors based upon traffic, weather, airspace restrictions and obstacles, aircraft capabilities, and pilot preferences. These DTerPs may include segmented or curved approaches. For all approaches, we will implement the minimum Glide Path Angles that satisfy visibility geometry requirements, local land use and noise abatement regulations, obstacles, and provide maximum pilot transition time within those constraints. When ground-based DTerPS has been proven to be feasible, we plan to explore airborne algorithms that will exploit ADS-B capabilities to establish RTA windows for DTerPs, and provide velocity cues among the aircraft. As in the in-trail procedures, we will progress this line of experimentation from a relatively simplistic approach toward an object-oriented 4D flight trajectory sequencing system that can be implemented among participating aircraft, with little or no ground infrastructure.

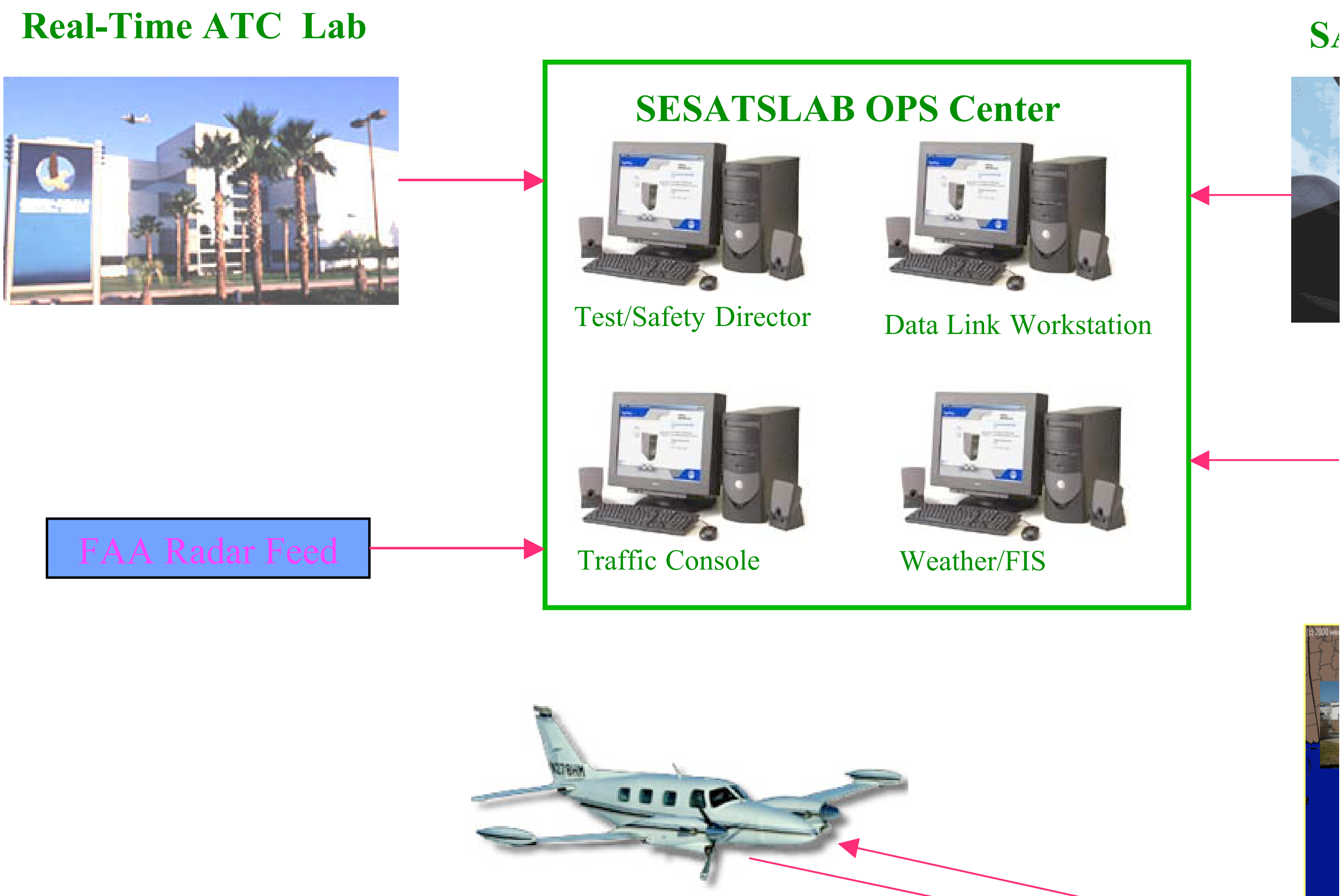
Changes From Current Operations, Procedures, or Policies

Specific procedural modifications we will be investigating include:

- In-trail operations – Collaboratively sequenced operations at single runways, in which each active aircraft in the terminal coverage area that has requested an approach or departure clearance is assigned a leader aircraft or sequence number and datalink velocity instructions for following the leader aircraft in the sequence at a specified distance.
- Required Time of Arrival Operations - Collaboratively sequenced operations at single runways, in which each active aircraft in the terminal coverage area that has requested an approach or departure clearance is assigned an RTA window and timespan, and datalink velocity instructions for meeting the RTA time and position requirements.
- Staggered and simultaneous collinear approaches and departures for long runways (>7500 feet) with midfield exits – Operations at runway ends and midpoints
- Staggered and simultaneous operations for intersecting runways – Divergent departures and convergent approaches; LAHSO;
- Dynamic Terminal Procedures (DTerPs) – Initially, ground segment dynamic approach assignment among fixed, obstacle-free approach paths depending on traffic, and weather, eventually leading to increased dynamic airborne adaptation including aircraft capability, and pilot preference.
- Conflict Detection and Resolution (CD&R) Operations – Initially ground segment processed rule-based traffic advisories for deconfliction, leading to increased dynamic adaptation based on ADS-B messages communicated among the active aircraft in the terminal coverage area.

Key Assumptions

1. Pilots and ground segment possess valid and timely information about ownership and other aircraft, terrain, obstacle, hazardous weather object, approach path, and runway position, and velocity.
2. Pilots possess knowledge of missed approach procedures.
3. HVO Functional Architecture



HVO Architecture Concept

3.0 CONCEPTS OF OPERATIONS FOR LOWER LANDING MINIMUMS

The lower landing minimum (LLM) conops are sub-elements of the overall terminal area conops. These terminal area conops can be either current ATC separation procedures or operational concepts developed for the SATS HVO operating capability. In addition, since the intent of the lower landing minimums operating capability is to support near-all weather operations from minimally equipped runways, the need to support safe, low-visibility takeoffs is part of this operating capability and conops for takeoff are included in this section. For commercial, Part 135 operations it is desired to enable takeoff visibility minimums that are at least equal to the lowest applicable landing minimums without additional airport or aircraft equipage beyond what is required to support the landing minimums. For part 91 operations, there are currently no regulatory takeoff minimum restrictions (i.e. takeoff with 0 visibility is legal). However, many private pilots impose personal takeoff visibility minimums equal to their landing minimums.

For airport arrivals, the LLM conops begins at the point beyond which a series of predetermined maneuvers must be performed by reference to flight instruments with specified protection from obstacles (typically the initial approach fix) and ends upon runway exit, or if a landing is not completed upon reaching a condition where holding or en route obstacle clearance criteria apply. For airport departures, the LLM conops begins when the active runway is entered and ends when holding or en route obstacle clearance criteria apply. The common feature of these phases of flight is that terrain and obstruction clearance concerns limit the available maneuvering options and during normal operations, pre-defined approach and departure corridors (i.e. published approach and departure procedures) shall be utilized. The ability of GPS-WAAS navigation to support segmented or curved flight paths may allow multiple corridors to be defined for a given runway end and these corridors could be assigned as needed to support the HVO conops.

The primary challenges of this operating capability are developing technologies and procedures that allow the airspace and ground protection zones and approach lighting requirements defined in FAR Part 97 (e.g. TERPS) and airport design criteria (e.g. AC150/5300-13) to be redefined such that near-all weather operations can be conducted at otherwise VFR runways. In addition, noise considerations may require approach and departure paths that are designed to minimize the noise impact on the surrounding community. For example, overhead, circling approaches could be used to keep the noise footprint largely over the airport boundaries and steep approaches or departures could reduce the extension of the noise impact outward from the runway ends.

<u>Minimum Requirement</u>: Demonstrate the ability to provide precision like approach and landing guidance that requires no new land acquisition, no approach lighting, and minimal new ground-based equipment with minimum ceiling and visibility requirements of 200 ft and 1/2 miles respectively at a currently VFR-only airport

<u>Target Requirement</u>: Demonstrate the ability to provide precision like approach and landing guidance that requires no new land acquisition, no approach lighting, and minimal new ground-based equipment with no ceiling requirements and a visibility requirement of 1/4 mile at a

currently VFR-only airport

3.1 CONCEPT LLM-A

Except for the final stage of an approach (i.e. prior to the final 400' AGL) the conops for reference and target performance levels are identical and will be described together. The final stage of the approach will then be described separately. Note that the term airplane is used to denote the combination of the airplane, its systems, and the pilot; it does not denote an a priori allocation of a function to technology.

Assumptions and constraints: For the purposes of this operating capability, the runway is assumed to have a paved surface at least 3000' in length and 60' in width. In addition, this runway is assumed to have a runway edge light system. Only aircraft in approach categories A (approach speed <90 knots) and B (approach speed 90 knots and greater but less than 121 knots) shall be considered. Only aircraft in airplane design group I (wing span less than 49 feet) and with gross takeoff weight less than 12,500 lbs shall be considered.

Since a key element in the difficulty of a low-visibility landing is the time between break-out (i.e. visual confirmation of the runway environment) and touchdown, it is assumed that as glideslopes and approach speeds are increased, the decision height (DH) will also be increased. For example to maintain a constant time interval between breakout and touchdown the DH for a 6 degree glideslope will be approximately twice as high as the DH for a 3 degree glideslope. Similarly, the DH for an airplane with a 120 kt approach speed would need to be approximately twice the DH for an airplane with a 60 kt approach speed in order to keep this interval constant. Thus, if a runway requires a steep final glideslope to ensure obstacle clearance, this runway will require a higher DH than a runway without such an obstruction. Similarly, airplanes in approach category B will require higher minimums than airplanes in approach category A. The success requirements listed above are assumed to pertain to an approach category A aircraft and a runway that does not require a final glideslope steeper than 3 degrees.

Although no ceiling requirement (i.e. really a DH requirement) is listed for the stretch goal, it is assumed that at the given visibility minimum (i.e. 1/4 mile) and for a specified glideslope, a missed approach must be performed if the external airport environment has not been acquired upon reaching the DH. For example, for a 3-degree glideslope, the DH would be 70 feet (0.25 * 5280 *sin(3)).

3.1.1 Arrival and Landing Phase

Minimum and target conops excluding final 400' AGL of approach: The basic path segments used to build an approach or departure procedure can be defined and evaluated independently from the minimums associated with that procedure. Because of this independence, a single set of candidate path segments and conops can be used for both the minimum or target performance goals. The exception to this statement is the final segment of an approach during which transition to runway environment references must be performed to obtain a safe, controlled touchdown and rollout. Conops for this final segment will be described separately.

Time Sequence of Events

Arrivals

Normal Operations

- Airplane receives clearance to execute one of the published approach procedures
- Airplane executes approach procedure per clearance and either lands or executes appropriate missed approach procedure.
- If airplane lands, exits runway via-
  - turn off onto parallel taxiway
  - taxis / back taxis as need to reach nearest exit
- If missed approach, airplane arrives at assigned missed approach holding pattern/altitude and is re-sequenced or cleared to alternant airport

Abnormal Operations

- System failure, loss of
  - Communications
    - Voice
    - Data
  - Navigation Sensor
    - Primary navigation sensor
    - Secondary navigation sensor
  - Surveillance
    - ADS-B
    - Small terminal Sensor
  - Any single element, or combinations of element failures not shown to be extremely improbable, of the flight systems that the airplane is employing to perform the procedure.

Conops for final 400' AGL of approach

During the final 400' prior to touchdown, the reference and target conops differ due to the differences in visibility and decision height and the resulting derived requirements.

Minimum conops:

Time Sequence of Events

Normal Operations

- With sufficient time prior to decision height to achieve stabilized flight (estimated to be 0.5 miles at 90kts), the approach path transitions to a straight segment with a slope between -3 and -6 degrees. This straight segment simplifies the task of visually acquiring the runway environment by creating a constant azimuth angle to the runway.

- Prior to DH, the pilot attempts to acquire, distinctly identify visual references for the intended runway and assess whether a normal landing can be completed (i.e. the airplane is positioned such that a descent to a landing on the intended runway and in the intended touchdown zone can be made at a normal rate of descent using normal maneuvers).
- If the pilot determines that a normal landing can be performed, the pilot transitions to external references to establish and maintain a safe descent to the runway and completes the landing visually.
  - If flight-path control up to this point has been performed by a coupled autoflight system, the pilot must disconnect the system and complete the landing visually (this assumes the navigation system is not certified for use below 200')
- If the runway environment is not acquired, identified, or the airplane is not positioned to perform a normal landing when the DH is reached, the pilot initiates the missed approach procedure contained in the clearance, and the airplane executes this procedure.

Target conops:

Achieving the target performance level requires a much higher reliance on technology than does the reference performance level. For routine single-pilot operations an autoland system is probably the most practical approach and is assumed in this conops. To be certifiable, this autoland system probably requires failure-operational capability. In addition, the low visibility level of the target concept and the relatively non-sterile runway environment of many small airports (e.g. wildlife or ground vehicles could be present) virtually mandates some sort of active sensor to detect these dynamic hazards. For two-pilot operations, manual control combined with a heads-up display (HUD) system would also be feasible but is not considered in the current conops due to the program's focus on single-pilot operations.

Time Sequence of Events

Normal Operations

- Prior to initiating the approach, the proper functioning of autoland and high accuracy navigation systems (e.g. GPS LAAS) is verified by built-in tests
- Prior to descending below 400', the autoland system is engaged
- During the descent, the pilot monitors the autoland system and activates a missed-approach mode if nominal tolerances are exceeded. (The automation may also provide similar monitoring.)
- During the descent, a real-time sensor system verifies that the runway is clear of hazardous obstructions. If a hazard is detected, a missed approach is nominally performed
  - This system could provide an enhanced image to the pilot or merely provide a warning to the pilot if an obstruction is detected.
- If visual acquisition and identification of the runway environment is possible upon

reaching the DH, the pilot allows the approach to continue and monitors the external situation for proper flight-path behavior and hazards not indicated by the sensor system. The pilot remains poised to activate the missed-approach mode until the airplane has landed and braking commenced. If the pilot has not identified the runway environment upon reaching the DH, he nominally commands for the autoland system to execute a missed approach.

- During the rollout the pilot resumes manual control of the aircraft. In the absence of pilot action, the autoflight system tracks the runway centerline and slows the aircraft to a stop.

3.1.2 Departures

Normal Operations

- Airplane receives clearance to execute one of the published departure procedures
- Airplane verifies (e.g. visually, electronically) that runway and approach path are clear, enters the runway and taxis into position
  - May require significant taxi time for some wind directions
- Airplane executes published departure procedure and holds at published location/altitude if further clearance not yet received

3.1.3 Mixed-Equipage

3.1.4 Non-Normal Operations

3.1.5 Rare-Normal Operations

3.2 CONCEPT LLM-B

(This is Maryland Mid-Atlantic SATSLab Conops)

Description of concept of operations by relevant phase of flight.

3.2.1 Departure

During times of limited visibility due one or both nighttime and weather limiting visibility, the SATS pilot has several advantages over the non SATS pilot by virtue of his scotopia, or the ability to "see" during conditions of reduced visibility.

For airport departures, the LLM ConOps begins as the single pilot taxies onto the active runway either having been "cleared for takeoff" by an Air Traffic Controller" (at a controlled airport), or self clearing by observing the approach path and runway (at a non-controlled airport). The LLM ConOps for departures ends when the pilot has taken off, climbed, and reached the point where the en-route portion of the flight begins and en-route obstacle clearance criteria apply.

The single pilot, by looking through the combining glass of the Head Up Display (HUD) ensures that he (she) can see the runway surface directly in front of the aircraft. The pilot's observance accomplishes two things: (1) allows the pilot to observe the runway and spot runway incursions and obstacles, and (2) allows the pilot to align the aircraft with the runway and confirm this aircraft-runway alignment with the on-board compass.

The single pilot, having confirmed that the runway is free of obstacles, is now free to conduct a normal takeoff. While on the runway, the pilot simply observes the runway, and his alignment to the runway center, by looking through the aircraft windscreen (and thereby the HUD). Visual information that is gleaned by the pilot during this limited visibility takeoff is similar to the visual information available during VFR conditions.

The single pilot not only observes the runway by looking through the aircraft's windscreen, but also has all the necessary aircraft performance information pertinent to the takeoff presented in front of the pilot's head (superimposed on the windscreen by virtue of the HDD).

Upon the aircraft's having reached an airspeed sufficient to permit rotation, the single pilot reverts to flying the aircraft by use of aircraft performance and navigation information provided by his on-board instruments. At rotation, when the aircraft nose points up relative to the runway, no further visual information is possible, and the single pilot continues the climb, then transitions to the en route portion of the flight, under IFR.

3.2.2 En Route

Lower Landing Minimums (LLM) are not applicable to En Route Operations.

3.2.3 Descent and Arrival

For airport arrivals, the LLM ConOps begins as the single pilot must begin a set of flight maneuvers by reference to flight instruments to stay clear of obstacles on approaching the airport runway. The LLM ConOps ends upon the pilot exiting the active runway, or if a full stop landing is not completed, then flying to a predetermined (published) point.

The single pilot, upon approaching the desired airport of arrival, selects the appropriate standard procedure for instrument letdown under IFR, which is graphically displayed on his on-board multi-functional display.

Upon approaching the final en route leg to destination airport, the ATC controller will issue descent and approach clearances consistent with the planned arrival. ATC will assign estimated approach times to SATS aircraft flight plans, which will function as the approach sequence for all SATS aircraft. The SATS aircraft will automatically exchange this information for the purpose of self-separation and self-sequencing for the approach and landing. The SATS aircraft will also receive updated TIS, FIS, and weather information from the airport's digital communication interface to the NIS if available.

The single pilot, having been either "cleared to land" (controlled airport) or "cleared for the approach" (non-controlled airport), makes the appropriate turns and decent altitude changes by reference to the approach plate graphically presented on the multifunction display, with the aircraft's position superimposed both horizontally and vertically. The single pilot's situational awareness with respect to his/her position relative to the runway is enhanced through the ability to graphically visualize both the aircraft's position and the published approach on one display.

The single pilot's situational awareness with respect to the terrain and ground obstacles during the approach to the runway is enhanced by the display of a virtual representation of the terrain along and to the side of the ground path of the aircraft.

The pilot flies "head up" and observes this virtual representation of the terrain (and any obstacles) along his intended ground path, and the runway, by looking through the HUD and the aircraft's windscreen. As the pilot descends and the distance to the runway decreases, the virtual representation of the runway is gradually and seamlessly replaced with an enhanced visual image of the runway.

The aircraft's pertinent aircraft performance information, i.e., velocity vector etc. and pertinent navigation information, i.e., altitude above ground level (AGL) are superimposed on the HUD glass, allowing the single pilot to fly the entire approach to landing head up and by observing the runway landing area.

The single pilot either lands the aircraft and taxies off the runway onto a taxiway, or if landing conditions are not satisfactory to the pilot (not able to "see" the runway environment or obstacle on the runway), the pilot initiates missed approach and flies to a designated point (as indicated on the standard approach procedure).

3.2.4 Mixed Equipage Operations

Because SATS and non-SATS aircraft conduct departures and landings using standard instrument procedures, both SATS and non-SATS departures and arrivals are compatible in a "mixed' environment. While the enabling vision technology may capture incidental aircraft images on the primary flight display during landing and departing phases of flight, it is not envisioned as a tool for separation assurance with other aircraft.

3.2.5 Non Normal Operations

While conducting an approach that transitions from IFR to VFR with the airport in VMC, all aircraft must obey see-and-avoid procedures. However, all SATS aircraft will continue to broadcast their identification and position vectors. The SATS aircraft computer system will continue to monitor self-separation with all objects (aircraft, terrain, airspace boundaries, weather, etc.) and conformance with spacing for self-sequencing.

Given a failure of the LLM vision system, landing and departure operations will conform to the published procedures for standard navigation equipage. If the ceiling and visibility are below the published approach with standard navigation equipment, the aircraft will execute a missed approach and navigate to its alternate airport with ATC instructions.

3.2.6 Rare-Normal Operations

SATS aircraft will have data link access to digital weather forecasts. In addition, SATS aircraft will automatically collect weather sensor data in-flight, and distribute the data to the NWS. Sensors on the SATS aircraft will also observe lightning strike incidents in localized severe weather cells and the computer system will create a composite weather picture with other data for display to the pilot. Convective weather at the airport may be detected by local AWOS and superimposed by the aircraft computer on the pilot's display. The SATS aircraft computer will automatically calculate and display graphic separation criteria for pilot to maintain clear of severe weather cells.

SATS aircraft LLM vision sensors may improve the pilot's ability to locate non-transponding aircraft when operating in non-radar airport airspace.

Similarly, the on-board SATS computers will fuse digital, sensor vision, and traffic information on the HUD. The combination of these features on an out-the-window display and superimposed over the flight path will reduce the potential for single pilot-induced errors during the flight critical phases of approach, landing, and departure.

3.3 Concept LLM-C

(This is Southeast SATSLab Conops)

Introduction

Overview and general philosophy of the CONOPS

Hypothesis: Aircraft can safely land at currently VFR airports through implementation of airborne and ground based avionics and CNS/ATM technologies, coupled with improved flight operations procedures, under CAT I IMC or worse visibility conditions.

Initial experiment activities will include the use of Automatic Dependent Surveillance – Broadcast (ADS-B), based upon the Global Positioning System (GPS) and the Wide Area Augmentation System (WAAS) with local integrity monitoring (LWIM) to provide pilots and ground facilities with accurate aircraft position information. The aircraft will be equipped with the latest in Cockpit Display of Traffic Information (CDTI), moving maps, text and graphic weather products, and Highway in the Sky (HiTS) perspective displays. These will enable the test pilots to operate in simulated IMC much as they could in Visual Meteorological Conditions (VMC). Our initial target will be 200 foot ceilings and 2400 feet visibility (Category I – CAT I), and we will strive to achieve lower minimums. Glide path angles of the approaches will be dictated by the minimum GPA geometry required to meet the visibility conditions, to provide the pilot with maximum transition time.

The LLM project will consist of a series of experiments and demonstrations that show how enabling technologies and innovative procedures can improve on small airport availability during IMC.

We plan to develop and fly the following kinds of terminal area procedures under IMC to increase small airport availability: These procedures depend on accurate, reliable location knowledge of the aircraft position, approach thresholds, runway touchdown points, runway exit paths, and aircraft sequencing, for maintenance of operational safety. All flight experiments will be simulated prior to flight, and safety pilots will be utilized. We will simulate Category I IMC conditions (200 feet & _ Mile) for initial experiments and lower minimums as we progress.

WAAS Approaches under Simulated CAT I IMC

These will be simple variants of GPS approaches with WAAS correction.

WAAS Approaches under Simulated CAT I IMC with Local Integrity Monitor

This series of experiments will add a datalink WAAS integrity message to the pilot's information during approach operations so that (s)he can abort the approach in timely fashion if there is a problem with the GPS/WAAS signal integrity. This message will be available to the pilot within the FAA six second requirement. If WAAS integrity is insufficient to conduct the approach, the pilot will be advised to execute a missed approach.

WAAS Approaches under Simulated CAT I IMC with Synthetic Vision System

This series of experiments will utilize the Goodrich Smart Deck, and perhaps other SVS (e. g. Avidyne, Chelton) for comparison, to show potential improvements in small airport availability under reduced visibility conditions.

WAAS Approaches under Simulated CAT I IMC with Synthetic Vision System and Low Cost Airport Radar

This series of experiments will add local weather event and Mode-C Intruder information to the synthetic vision information to provide the pilot with near real-time information about weather events or non-equipped traffic in the terminal area.

WAAS Approaches under Simulated CAT I IMC with Enhanced Vision System (EVS)

This series of experiments will utilize low-cost forward or side looking Infrared technology and/or low-light video technology to provide runway imagery overlaid on the synthetic vision display. We will also explore the possibilities of a low cost Approach Lighting System (ALS) alternative that would add active emitters in the IR or visible range to provide enhanced definition of runway end/centerline.

WAAS Approaches under Simulated CAT I IMC with Advanced Control System

This series of experiments will utilize the Avidyne HiTS/MFD Display, with advanced decoupled flight controls to show potential further improvements in small airport availability under reduced visibility conditions by further simplifying the pilot's flightpath management task.

Silent Sentry System (S3) Approaches under Simulated CAT I IMC

This experiment series depends upon verification that the Silent Sentry technology meets the needs of SATS, and a joint NASA, SATSLab decision to fund exploratory experiments involving the use of S3 technology to provide cockpit display of traffic information along with synthetic vision. We have proposed to plan and participate in a joint experiment with the other SATSLabs and the Lockheed Martin Company to explore the S3 capabilities for passive terminal area surveillance, and runway incursion monitoring. This experiment will be carried out in 2002 at Gaithersburg, MD, where the LMCO S3 prototype is located. Maryland SATSLab, NCUGP SATSLab, and Virginia SATSLab have agreed to participate in this collaborative experiment with us, and the detailed planning needs to be accomplished. This would be a good initial flight for NASA aircraft since little additional equipment is needed in the aircraft.

Basically, the experiment would consist of one or more SATS aircraft flying standard approaches to Gaithersburg against the SS-3 prototype. The SATS aircraft would have their beacons turned off for the approach. Their position would be recorded using flight data recorders to measure their position vs. GPS time. The SS-3 would also be synched to GPS time, and its performance in detecting and locating the aircraft would be recorded for comparison with the recorded flight data.

Simultaneously, one or more ground vehicles equipped with GPS receivers and position recorders would maneuver around the airport surface movement area. We would also evaluate SS-3's ability to detect and locate these vehicles as potential runway incursions.

Changes From Current Operations, Procedures, or Policies

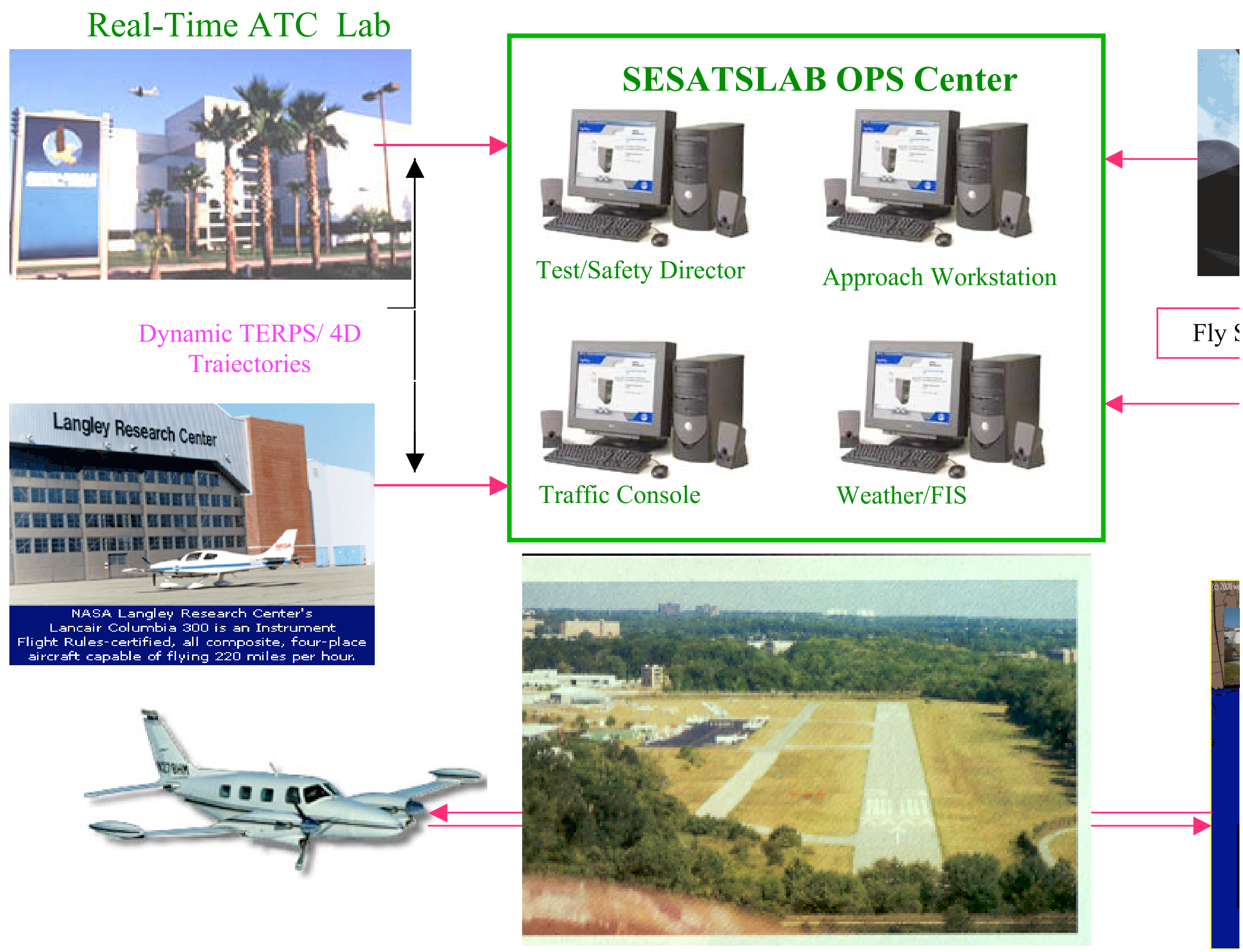
Specific simulations and experimental flights we plan to conduct include:

- WAAS/SVS/HITS approaches with Local Integrity Monitoring in VMC under simulated IMC
- WAAS/EVS/HITS approaches with Local Integrity Monitoring in VMC under simulated IMC
- WAAS/SVS/HITS approaches with Wx and Traffic information from the low-cost airport radar under simulated IMC.

Key Assumptions

1. Pilots and ground segment possess valid and timely information about ownership and other aircraft, terrain, obstacle, hazardous weather object, approach path, and runway position, and velocity.
2. Pilots possess knowledge of missed approach procedures.

3.



3.8 Concept LLM-H

LLM Architecture Concept

The overall objective of the Lower Landing Minima Concepts of Operations is to maximize access to airports that are encumbered by obstructions or noise abatement. The current restriction to 3 degree approaches causes the need to raise minimums for takeoff and landing in order to account for controlling obstacles. If the glide path angle could be increased or course segmented, these airports could increase availability by lowering the minima. To that end, a variety of solutions can be explored. Automation to improve situational awareness and provide guidance to the pilot can be incorporated to ensure performance equivalence to an ATP pilot, even for pilots just receiving their instrument rating. This ConOps is specifically related to Straight In approaches, that is, course is held constant. The LLM ConOps integrate with HVO at the FAF and incorporate a variety of technologies and procedures consistent with SPS.

Definition of Terms

- Straight in approach: Glide path angle and course are constant for the duration of the approach.
- Steep Approach: Glide path angle is greater than 3 degrees and is held constant for the duration of the approach.
- Vertically Segmented Approach: Glide path variation while course is constant for the duration of the approach. The segment is defined by a change in glide path angle.

Changes to Operations, Procedures, or Policies

There are no significant changes from today's operations, procedures, or policies that are not already under consideration (e.g. WAAS APV 1.5 Minimums)

Key Assumptions

- Mixed-equipage must be permitted, no mandated equipment for conditions that currently permit an approach. No denial of access to current VFR or IFR aircraft or pilots in conditions when they can currently make an approach. New equipment is only required to take advantage of new lower minimums approaches.
- Assume all aircraft are properly sequenced and separated when they reach the IAF and the FAF. Based on HVO ConOps.
- Assume maximum approach and departure speed differential of 40 knots.
- Just as with current IFR approaches which occur in VMC, pilots must be able to see and avoid VFR traffic.
- FAA will publish special authorization requirements (SAR) terminal arrival procedures and instrument approach procedures (IAPs) approaches to accomplish combined HVO and LLM operations.
- FAA creates published curved approach to avoid terrain and obstacles at VFR airports and non-precision IFR airports.
- Electronic and paper charts must be coded to signify curved approach.

- Assumed WAAS operation at follows:
  - If WAAS signal available, get WAAS minima.
  - If WAAS signal unavailable, but have 6 satellites in view, get FDE minima.
  - If less than 6 satellites in view, get RAIM minima (LNAV).
  - If RAIM unavailable, ded reckoning.

Functional Architecture

Automation and precision navigation systems will be used to achieve the level of safety consistent with an ATP pilot. This automation may include HITS displays, flight directors, autopilots and flight controls. The objective is to provide increased access to airports not currently available with visibility below 250' and 1 mile. All approaches are GPS/WAAS based and require no additional lighting at the airport.

Proposed Air Traffic and Flight Operations Event Sequences

Air Operations

Arrivals

Normal Operations

Steep Single Vertical Segment Normal Operations event sequence

- ATC must confirm pilot is on non-standard, SATS-SAR approach. ATC callout will include new name for the approach.
- Pilot is cleared to IAF and cleared for the SATS-SAR Single Vertical Segment approach, which will differ from the standard T approach in the vertical dimension.
- Prior to reaching final approach fix (FAF), pilot configures airplane properly, and reduces power sufficiently to achieve desired glide path angle (GPA).
- Pilot flies published SATS-SAR approach with steep glides slope (e.g. 5 degrees) to avoid terrain or obstacles which otherwise would result in higher minimums on the straight-in approach all the way to flare.
- Avionics provide situational awareness, or decision aiding (including alarms when boundary conditions are exceeded), or coupling of approach and cues for approach segment and flare.

Steep Dual Vertical Segment (5 and 3 degrees) Normal Operations event sequence

- Pilot is cleared to IAF and cleared for the SATS-SAR Dual Vertical Segment approach, which will differ from the standard T approach in the vertical dimension.
- Prior to reaching final approach fix (FAF), pilot configures airplane properly, and reduces power sufficiently to achieve desired glide path angle (GPA).

- Pilot flies published SATS-SAR approach with steep glides slope (5 degrees) to avoid terrain or obstacles which otherwise would result in higher minimums on the straight-in approach to the second segment, add power to reduce GPA to 3 degrees.
- Avionics provide situational awareness, or decision aiding (including alarms when boundary conditions are exceeded), or coupling of approach and cues for initial segment, transition to second segment and flare.

Rare Normal Operations

Adverse Weather

Same conditions apply for current approach and landing scenarios.

Traffic in excess of capacity

Same conditions apply for current approach and landing scenarios.

Pilot Errors

Same conditions apply for current approach and landing scenarios.

Controller Errors

Same conditions apply for current approach and landing scenarios.

Abnormal Operations

Abnormal Operations are those leading or potentially leading to clearance nonconformance or other unsafe situations.

System Failures

Loss of Communications Landing operations continue under existing loss of communications procedures.

Loss of Navigation

- Prior to initiating the approach, pilot will determine navigational accuracy category (NAC) and navigational integrity category (NIC) against the SAR requirements. This will be conveyed with a flag where out of
- If the navigation system being used for the landing is lost or NAC/NIC fall below required levels during the approach, the pilot should not initiate approach.
- The Pilot then must analyze whether the SATS approach can be executed with a secondary navigation source, including LORAN, or ATC radar vectors, if available.
- If not able to execute the SATS approach, then the pilot should request a traditional approach, precision or non-precision (with higher minima if weather would permit), or divert to an alternate airport.

Loss of Surveillance No effect on landing, unless a surveillance approach is used as a backup.

Loss of Weather information

- Loss of weather information may affect the approach if the pilot is aware of hazardous weather conditions in the terminal area, as a matter of prudence.

- No requirement to have weather info to start the approach for Part 91.
- For Part 135, need airport weather to begin approach, could be from nearby airport or data link info.. Cite.
- Once begun, parts 91 and 135 can continue the approach without additional weather.

Loss of Flight Information Pilot must determine whether the capability exists to continue approach or to execute a missed approach, based on SAR requirements.

Loss of Automation

- Pilot must determine whether the capability exists to continue approach or to execute a missed approach, based on SAR requirements.
- Automation would include:
  - Situations awareness displays, such as HITS, SPI, etc.
  - Decision aiding, such as cues for pull out.
  - Coupled Controls.

Deliberate Pilot Misuse

Pilot training and AIM guidance on the hazards

3.4 CONCEPT LLM-D

(This is Virginia SATSLab Conops LLM1)

Introduction

Overview and Philosophy of Con OPS

The overall objective of the Lower Landing Minima Concepts of Operations is to maximize access to airports that are encumbered by obstructions or noise abatement. The current restriction to 3 degree approaches causes the need to raise minimums for takeoff and landing in order to account for controlling obstacles. If the glide path angle could be increased or course segmented, these airports could increase availability by lowering the minima. To that end, a variety of solutions can be explored. Automation to improve situational awareness and provide guidance to the pilot can be incorporated to ensure performance equivalence to an ATP pilot, even for pilots just receiving their instrument rating. This ConOps addresses horizontally segmented approaches. The LLM ConOps integrate with HVO at the FAF and incorporate a variety of technologies and procedures consistent with SPS.

Definition of Terms

- Straight in approach: Glide path angle and course are constant for the duration of the approach.
- Horizontally Segmented Approach: Glide path angle is held constant and course is varied

during the approach.

- Segment is defined by a change in course heading.

Changes to Operations, Procedures, or Policies

Key Assumptions

- Mixed-equipage must be permitted, no mandated equipment for conditions that currently permit an approach. No denial of access to current VFR or IFR aircraft or pilots in conditions when they can currently make an approach. New equipment is only required to take advantage of new lower minimums approaches.
- Assume all aircraft are properly sequenced and separated when they reach the IAF and the FAF. Based on HVO ConOps.
- Assume maximum approach and departure speed differential of 40 knots.
- Just as with current IFR approaches which occur in VMC, pilots must be able to see and avoid VFR traffic.
- FAA will publish special authorization requirements (SAR) terminal arrival procedures and instrument approach procedures (IAPs) approaches to accomplish combined HVO and LLM operations.
- FAA creates published curved approach to avoid terrain and obstacles at VFR airports and non-precision IFR airports.
- Electronic and paper charts must be coded to signify curved approach.
- Assumed WAAS operation at follows:
  - If WAAS signal available, get WAAS minima.
  - If WAAS signal unavailable, but have 6 satellites in view, get FDE minima.
  - If less than 6 satellites in view, get RAIM minima (LNAV).
  - If RAIM unavailable, ded reckoning.

Functional Architecture

Automation and precision navigation systems will be used to achieve the level of safety and accuracy consistent with an ATP pilot. This automation may include HITS displays, flight directors, autopilots and flight controls. The objective is to provide increased access to airports not currently available with visibility at or above 250’ and 1 mile. All approaches are GPS/WAAS based and require no additional lighting at the airport.

Proposed Air Traffic and Flight Operations Event Sequences

Air Operations

Arrivals

Normal Operations

Single Horizontal Segment Higher Runway Offset Normal Operations event sequence

- Pilot is cleared to IAF and cleared for the SATS-SAR Single Horizontal Segment approach, which will differ from the standard T approach in the horizontal dimension.
- Prior to reaching final approach fix (FAF), pilot makes heading change as required for higher offset SATS-SAR approach.
- Pilot flies published SATS-SAR approach with higher runway offset to avoid terrain or obstacles which otherwise would result in higher minimums on the straight-in approach all the way to the runway threshold.
- Avionics provide situational awareness, or decision aiding (including alarms when boundary conditions are exceeded), or coupling of approach and cues for visual approach segment and final alignment turn.

Dual Horizontal Segment Normal Operations event sequence

- Pilot is cleared to IAF and cleared for the SATS-SAR Dual Horizontal Segment approach, which will differ from the standard T approach in the horizontal dimension.
- Prior to reaching final approach fix (FAF), pilot configures airplane for approach GPA, and intercepts change for intermediate segment.
- Pilot flies published SATS-SAR approach with steep glides slope (5 degrees) to avoid terrain or obstacles which otherwise would result in higher minimums on the straight-in approach to the second segment, add power to reduce GPA to 3 degrees.
- Avionics provide situational awareness, or decision aiding (including alarms when boundary condition are exceeded), or coupling of approach and cues for initial segment, transition to visual segment.

Rare Normal Operations

Adverse Weather

Hazardous weather must be evaluated to determine effects to safety of flight. Weather judgments are similar to the current procedure.

Traffic in excess of capacity

Same conditions apply for current approach and landing scenarios.

Pilot Errors

Same conditions apply for current approach and landing scenarios.

Controller Errors

Same conditions apply for current approach and landing scenarios.

Abnormal Operations

System Failures

Loss of Communications

Landing operations continue under existing loss of communications procedures.

Loss of Navigation

- Prior to initiating the approach, pilot will determine navigational accuracy category (NAC) and navigational integrity category (NIC) against the SAR requirements.
- If the navigation system being used for the landing is lost or NAC/NIC fall below required levels during the approach, the pilot should execute a missed approach.
- The Pilot then must analyze whether the SATS approach can be executed with a secondary navigation source, including LORAN, or ATC radar vectors, if available.
- If not able to execute the SATS approach, then the pilot should request a traditional approach, precision or non-precision (with higher minima if weather would permit), or divert to an alternate airport.

Loss of Surveillance

No effect on landing, unless a surveillance approach is used as a backup.

Loss of Weather information

Loss of weather information may affect the approach if the pilot is aware of hazardous weather conditions in the terminal area.

Loss of Flight Information

Pilot must determine whether the capability exists to continue approach or to execute a missed approach, based on SAR requirements.

Loss of Automation

Loss of automation impact depends on whether the approach complexity requires the use of automation to successfully complete the approach. Automation would include:

- Situations awareness displays, such as HITS, SPI, etc.
- Decision aiding, such as cues for pull out.
- Coupled Controls.

Deliberate Pilot Misuse Pilot training and AIM guidance on the hazards of misuse.

3.10 CONCEPT LLM-E

(This is Virginia SATSLab Conops LLM-2)

Introduction

Overview and Philosophy of Con OPS

The overall objective of the Lower Landing Minima Concepts of Operations is to maximize access to airports that are encumbered by obstructions or noise abatement. The current restriction to 3 degree approaches causes the need to raise minimums for takeoff and landing in order to account for controlling obstacles. If the glide path angle could be increased or course segmented, these airports could increase availability by lowering the minima. To that end, a variety of solutions can be explored. Automation to improve situational awareness and provide guidance to the pilot can be incorporated to ensure performance equivalence to an ATP pilot, even for pilots just receiving their instrument rating. This ConOps addresses horizontally and vertically segmented or Compound approaches. The LLM ConOps integrate with HVO at the FAF and incorporate a variety of technologies and procedures consistent with SPS.

Definition of Terms

- Straight in approach: Glide path angle and course are constant for the duration of the approach.
- Horizontally Segmented Approach: Course is variation.
- Vertically Segmented Approach: Glide path angle variation
- Segment: A change in glide path angle, course, or both.
- Compound Approach: Approach containing vertical and horizontal segments.

Changes to Operations, Procedures, or Policies

Key Assumptions

- Mixed-equipage must be permitted, no mandated equipment for conditions that currently permit an approach. No denial of access to current VFR or IFR aircraft or pilots in conditions when they can currently make an approach. New equipment is only required to take advantage of new lower minimums approaches.
- Assume all aircraft are properly sequenced and separated when they reach the IAF and the FAF. Based on HVO ConOps.
- Assume maximum approach and departure speed differential of 40 knots.
- Just as with current IFR approaches which occur in VMC, pilots must be able to see and avoid VFR traffic.
- FAA will publish special authorization requirements (SAR) terminal arrival procedures and instrument approach procedures (IAPs) approaches to accomplish combined HVO and LLM operations.
- FAA creates published curved approach to avoid terrain and obstacles at VFR airports and non-precision IFR airports.
- Electronic and paper charts must be coded to signify curved approach.
- Assumed WAAS operation at follows:
  - If WAAS signal available, get WAAS minima.

- If WAAS signal unavailable, but have 6 satellites in view, get FDE minima.
- If less than 6 satellites in view, get RAIM minima (LNAV).
- If RAIM unavailable, ded reckoning.

Functional Architecture

Automation and precision navigation systems will be used to achieve the level of safety consistent with an ATP pilot. This automation may include HITS displays, flight directors, autopilots and flight controls. The objective is to provide increased access to airports not currently available with visibility below 250' and 1 mile. All approaches are GPS/WAAS based and require no additional lighting at the airport.

Proposed Air Traffic and Flight Operations Event Sequences

Air Operations (and ground operations)

Arrivals (departures and en route operations)

Normal Operations

- Pilot is cleared to IAF and cleared for the SATS-SAR approach, which will differ from the standard T approach in the vertical and horizontal dimensions.
- Pilot flies published SATS-SAR approach with steep glides slope (up to 6 degrees), and with segments that exceed normal TERPS requirements, to avoid terrain or obstacles which otherwise would result in higher minimums on the straight-in approach.
- Upon reaching final approach fix (FAF), pilot configures airplane for highest drag/highest lift, and reduced power sufficiently to achieve desired glide path angle (GPA).
- Avionics provide situational awareness of approach and cues for final segment and flare.
- If a missed approach is required, pilot follows the published missed approach procedure.

Rare Normal Operations

Adverse Weather

Hazardous weather must be evaluated to determine effects to safety of flight. Weather judgments are similar to the current procedure.

Traffic in excess of capacity

Same conditions apply for current approach and landing scenarios.

Pilot Errors

Same conditions apply for current approach and landing scenarios.

Controller Errors

Same conditions apply for current approach and landing scenarios.

Abnormal Operations

System Failures

Loss of Communications

Landing operations continue under existing loss of communications procedures.

Loss of Navigation

- Prior to initiating the approach, pilot will determine navigational accuracy category (NAC) and navigational integrity category (NIC) against the SAR requirements.
- If the navigation system being used for the landing is lost or NAC/NIC fall below required levels during the approach, the pilot should execute a missed approach.
- The Pilot then must analyze whether the SATS approach can be executed with a secondary navigation source, including LORAN, or ATC radar vectors, if available.
- If not able to execute the SATS approach, then the pilot should request a traditional approach, precision or non-precision (with higher minima if weather would permit), or divert to an alternate airport.

Loss of Surveillance

No effect on landing, unless a surveillance approach is used as a backup.

Loss of Weather information
Loss of weather information may affect the approach if the pilot is aware of hazardous weather conditions in the terminal area.

Loss of Flight Information

Pilot must determine whether the capability exists to continue approach or to execute a missed approach, based on SAR requirements.

Loss of Automation

- Loss of automation impact depends on whether the approach complexity requires the use of automation to successfully complete the approach.
- Automation would include:
  - Situations awareness displays, such as HITS, SPI, etc.
  - Decision aiding, such as cues for pull out.
  - Coupled Controls.

Deliberate Pilot Misuse

Pilot training and AIM guidance on the hazards of misuse.

Departures

Normal Operations

- Pilot is cleared for the SATS-SAR departure.
- Pilot flies published SATS-SAR departure, which may include additional turns and shorter segments to avoid terrain or obstacles which otherwise would result in higher departure minimums.
- Avionics provide situational awareness of approach and cues for final segment and flare.

Rare Normal Operations

Adverse Weather

Hazardous weather must be evaluated to determine effects to safety of flight. Weather judgments are similar to the current procedure.

Traffic in excess of capacity

Same conditions apply for current departure scenarios.

Pilot Errors

Same conditions apply for current departure scenarios.

Controller Errors

Same conditions apply for current departure scenarios.

Abnormal Operations

System Failures

Loss of Communications

Landing operations continue under existing loss of communications procedures.

Loss of Navigation

- The loss of navigation should be evaluated during the flight planning process.
- Prior to initiating the takeoff, pilot will determine navigational accuracy category (NAC) and navigational integrity category (NIC) against the SAR requirements.
- If the navigation system being used for the takeoff is lost or NAC/NIC fall below required levels during the takeoff, the pilot should maintain runway heading and climb to minimum safe altitude and call ATC for vectors to VMC.
- If not able to execute the SATS departure, then the pilot should request a standard departure (with higher minima) and wait for the weather to improve to that required.
- The pilot should continue to execute the departure procedure, if able based on backup systems.
- The pilot can also call ATC and if guidance is available based on surveillance, may return to the airport or continue the departure.

Loss of Surveillance No effect on departure.

Loss of Weather Information Loss of weather information may affect the departure if the pilot is aware of hazardous weather conditions in the terminal area.

Loss of Flight Information Pilot must determine whether the capability exists to continue approach or to execute a missed approach, based on SAR requirements.

Loss of Automation

- Loss of automation impact depends on whether the departure complexity requires the use of automation to successfully complete the departure.
- Automation would include: Situations awareness displays, such as HITS, SPI, etc. Decision aiding, such as cues for pull out. Coupled Controls.

Deliberate Pilot Misuse Pilot training and AIM guidance

4.0 CONCEPTS OF OPERATIONS FOR SINGLE PILOT PERFORMANCE

The objectives of the Increased Single-Crew Safety and Mission Reliability (SPP) operating capability are enhanced situational awareness, appropriate workload and engagement, improved resource management (e.g. fuel, aircraft configuration), improved planning, improved error prevention and tolerance, and adherence to the other SATS goals. Collectively, these objectives will significantly improve safety. Additionally, mission reliability is enhanced through increased operational capability in low-visibility conditions and improved decision-making, reducing the need to cancel, abort, or divert flights due to weather.

The SPP operating capability covers all phases of flight. Therefore, the ConOps will be described at an overall level that applies to all phases of flight. The elements of SPP (ConOps, requirements, proposed solutions) must be consistent and coherent with respect to the other SATS operating capabilities and objectives such as affordability. As the ConOps and requirements for the other SATS operating capabilities become defined this document will change and correspondingly, this document will influence the other ConOps.

Because SPP is pervasive during a flight rather than a sequence of events, the conops presented in this document might more correctly be termed requirements (So shoot me!) Note that the term airplane is used to denote the combination of the airplane, its systems, and the pilot; it does not denote an a priori allocation of a function to technology.

Minimum Requirement: Demonstrate single-pilot precision, safety, and mission reliability equal to that of a single ATP crewmember with current instrumentation.

Target Requirement: Demonstrate single-pilot precision, safety, and mission reliability equal to that of a 2 ATP crewmembers with current instrumentation.

SPP Concepts of Operation (and Requirements)

- The pilot shall be provided with the information and control authority needed to fulfill their responsibility as the final authority as to the operation of the aircraft per FAR Part 91.3
- The pilot shall have sufficient situational awareness to respond appropriately in all

credible situations (i.e. comparable to the actions and decisions that ATP rated pilots would choose). This awareness should include appropriate comprehension, integration, and prediction of the following elements:

  - The state of the aircraft and its systems
  - Surrounding air traffic and likely intentions
  - Airport information
  - Airspace information
  - Applicable weather information
  - Terrain and obstacles
  - Flight rules and procedures
  - Active and proposed clearances

- The airplane shall be designed to facilitate prevention, detection, and recovery from errors by either the pilot or the systems
  - Data critical to flight safety shall be obtained from multiple, independent sources and autonomously crosschecked to detect errors and identify suspect information before use by the airplane or the pilot.
- The limited physical and cognitive abilities of the pilot shall not be exceeded during normal, rare normal, and abnormal situations not shown to be extremely remote or extremely improbable.
- Entry into a condition unnecessary for normal procedures and potentially hazardous (e.g. usual attitude, deviation from clearance) should require a deliberate action by the pilot
- In the absence of sustained pilot intent, the airplane should recover from potentially hazardous conditions without pilot action
- In the event of pilot incapacitation, the remaining occupants shall have a means of safely terminating the flight which does not create an undue hazard to other air traffic or persons and property on the ground

Assumptions and Constraints: The target users of this operating capability are expected to have a wide range of experience and frequency of use, from private pilots flying occasionally (e.g. monthly) to professional pilots flying daily in service of on-demand operations under Part 135 and fractional ownership operations under the proposed subpart K within part 91. In keeping with the focus of the SATS project on smaller aircraft operating in the terminal area, technologies developed for this operating capability will emphasize terminal operations at low flight speeds. Issues unique to transonic and high-altitude operations will not be investigated in detail during the program, but the need to provide for future accommodation is recognized and will be part of the conceptual design of SATS systems and procedures for SPP.

- Operation in Instrument Meteorological Conditions (IMC)
- There will be a mix of SATS equipped and non-SATS equipped aircraft in

operation.

- The target goals for the four operational capabilities have not been addressed in this document for 2010 operations.
- SATS minimum equipage defined as: ADS-B transceiver, GPS
- ?

4.1 CONCEPT SPP-A

This least technologically aggressive concept uses current control automation (e.g. 3 axis autopilot) and partial information complemation (i.e. 4-D (x, y, z, t) FMS with integrated flight planning capability and navigation display, flight and thrust directors, and tactical situation displays).

General description:

- This approach is an extension of the current state-of-the-art General Aviation flight deck environment to enable 4-D RNP operations. The following modifications are made to flight deck designs such as modern Raytheon and Cirrus aircraft.
- A graphical navigation and planning system that allows the pilot to plan a 4-D route based on RNP concepts and then monitor that route. This multi-function display should support integration of navigation, traffic, terrain, airspace, airport, communication, and weather information.
- A fuel management capability that is coupled to the 4-D navigation system and current conditions to provide an accurate prediction of range and fuel reserve limitations.
- An autopilot and attitude flight director that can be coupled to the 4-D plan.
- A thrust director that can be coupled to the 4-D plan and is integrated with the autopilot and flight director.
- Vertical Situation Display (VSD) and Horizontal Situation Display (HSD) elements that allow the pilot to monitor progress along complex approach procedures, anticipate path segment transitions, and provide awareness of relevant hazards such as terrain and obstructions. These elements could be implemented using perspective or planform concepts.
- Display elements that facilitate positional awareness of the runway environment during the final approach segment and rapid transition to visual flight references at breakout.
- The autopilot system and flight deck displays can be used to provide passive and active flight envelope awareness and protection.
- An emergency autoland function can be provided if an autothrottle is integrated with the autopilot system

Departure Phase

En Route and Transition

Descent and Arrival

Mixed Equipage

Non-Normal Operations

The following are the major assumptions made in the formulation of this concept of operations:

- The concept of an HVO Airport Operations Area is operationally feasible.
- The goal of this concept of operations is to facilitate achieving the program target goal of allowing 10 simultaneous operations in non-radar airspace.

Rare-Normal Operations

4.2 Concept SPP-B

SPP-B implements advanced information complemation and part-time control complemation, using familiar autopilot/autothrottle components.

General operations:

- In general, the aircraft complemation is allocated the following processes:
  - Monitoring of data,
  - Alerting and informing the pilot of deviations from expectations
  - Alerting and informing the pilot of pending tasks
  - Fusion and integration of data to present a perceptually consistent representation of the data,
  - Prognosis and prediction of current trends and situations,
  - Information (memory) storage, search, and recall.
  - Activation of decision aiding tools
  - Acting as a backup in the event of pilot incapacitation
- In general, the pilot is allocated with the following processes:
  - Interpretation of information
  - Diagnosis of non-normality
  - Selection from among alternatives
  - Performing all aviation during critical flight phases (i.e. operations below 200' agl)

  - Acting as backup to the complemation in the case of a machine failure.

- During operations above 200'agl, the pilot can command the flight path vector (i.e. airspeed, vertical speed, and track) through a control wheel steering and autothrottle system. The associated control inceptors are "actual[1] controls" used by the pilot to command the flight path. This system provides the only routine interface to the autopilot and autothrottle systems. A traditional mode control panel or coupling between the autoflight system and the navigation system are intentionally omitted. This single interface reduces the potential for mode confusion errors and the risk of the pilot completely being out of the aviate loop as can happen in fully coupled modes of operation. A variation of this system would have the control complemation couple to the path segment through the navigation system after the pilot had "manually" performed the transition from the previous segment and tracked the new segment for sufficient time to provide awareness of the new condition. Because this system is implemented using autopilot components, it has neither the integrity nor bandwidth to fly the airplane at low altitudes and the pilot is expected to use standard manual controls for takeoff and landing. During these phases, the pilot can typically focus most of their attention on the control task and workload saturation issues are manageable. The pilot may also need to use the standard controls in non-normal situations and the procedures, controls, displays, training, and currency requirements must consider these situations.
- The aircraft complemation provides guidance, reminders, and alerts to the pilot regarding the flight path.
- The aircraft complemation provides monitoring of all aspects of the flight including mission performance (compared to flight plan), aircraft performance, and system performance. The pilot is considered a system of the aircraft and therefore is monitored by the complemation.
- Flight planning and replanning (notional[2]) performed on a dedicated control and display element using the language of the National Airspace System (NAS) (as opposed to an FMS programming language). The language of the NAS will be defined in concert with the other elements and will be based on the anticipated NAS environment.

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[1] Actual: manipulation of the real thing. Actual controls for the aircraft will move the aircraft or cause the configuration to change. Make an input to one of these controls and things will happen. Actual displays describe the real condition of the aircraft and its systems (including the human) as well as the environment. There is a level of certainty involved with an actual display. If you see a mountain portrayed on your display, you can rest assured that the mountain is there

[2] Notional: manipulation of a representation of a real entity, but not that entity itself. For example, when creating a flight plan, the pilot can be viewed as moving a fictitious aircraft through a fictitious airspace. The creation of the plan does not move the aircraft, but at some level of detail, this notional aircraft is behaving like a real aircraft. Notional representations can be purely mental, can be sketched on paper maps, or described textually. They can even exist within a computer program. The purpose of this distinction is to insure that the pilot knows when what he or she is doing will move the real aircraft or not. Notional displays usually have a lower tolerance for certainty than do actual displays. A storm can be predicted to intersect with a flight path; it may or may not actually happen. However the pilot is trained and conditioned to understand that notional information is not as certain and should be suspect.

- Mission status should be salient to the pilot including abnormalities in mission status. Information should be comprehended at-a-glance (or better).
- There will be a clear distinction between displays and controls that actually represent and control the aircraft and environment (actual) and those that will be used for planning, prediction, 'what-if' exploration, and alternate development (notional). For example, no input to the notional device (such as a plan) will cause the aircraft to move at present or in the future. There should be no confusion regarding what the aircraft will do.

4.3 CONCEPT SPP-C

SPP-C combines the information complemation of SPP-B with full-time control complemation, requiring a flight critical fly-by-wire (FBW) command augmentation system.

General operations:

- In general, the aircraft complemation is allocated the following processes:
  - o Monitoring of data,
  - o Alerting and informing the pilot of deviations from expectations
  - o Alerting and informing the pilot of pending tasks
  - o Fusion and integration of data to present a perceptually consistent representation of the data,
  - o Prognosis and prediction of current trends and situations,
  - o Information (memory) storage, search, and recall.
  - o Activation of decision aiding tools
  - o Acting as a backup in the event of pilot incapacitation
- In general, the pilot is allocated with the following processes:
  - o Interpretation of information
  - o Diagnosis of non-normality
  - o Selection from among alternatives
  - o Performing all aviation during critical flight phases (i.e. operations below 200' agl)
  - o Acting as backup to the complemation in the case of a machine failure.
- The pilot commands the flight path at all times (chock to chock) through a command augmentation system that provides direct command of the relevant indices of performance (e.g. the flight path vector). This avoids the need for the pilot to be trained and current in two different methods of controlling the vehicle as needed in SPP-B.

- The aircraft complemation provides guidance, reminders, and alerts to the pilot regarding the flight path.
- The aircraft complemation provides monitoring of all aspects of the flight including mission performance (compared to flight plan), aircraft performance, and system performance. The pilot is considered a system of the aircraft and therefore is monitored by the complemation.
- Flight planning and replanning (notional[3]) performed on a dedicated control and display element using the language of the National Airspace System (NAS) (as opposed to an FMS programming language). The language of the NAS will be defined in concert with the other elements and will be based on the anticipated NAS environment.
- Mission status should be salient to the pilot including abnormalities in mission status. Information should be comprehended at-a-glance (or better).
- There will be a clear distinction between displays and controls that actually represent and control the aircraft and environment (actual) and those that will be used for planning, prediction, 'what-if' exploration, and alternate development (notional). For example, no input to the notional device (such as a plan) will cause the aircraft to move at present or in the future. There should be no confusion regarding what the aircraft will do.

4.4 CONCEPT SPS-D

(This is VA SATSLab ConOps Envelope Protection)

Aircraft is equipped with automation to prevent exceeding the performance envelope of the aircraft. Passive intervention displays warnings when speed or load factor limits are being approached. Active intervention will not permit flight control surfaces (or power settings) that result in exceeding design limits.

Introduction

Overview and Philosophy of Con OPS

Prevent the pilot from operating outside the performance envelope: exceeding Vne (because of pilot disorientation, or in high turbulence situation), high g loading above Vma (pilot disorientation), flying below stall speed and departing from controlled flight (poor pilot performance). This could include prohibited airspace for security purposes, or unsafe trajectories

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[3] Notional: manipulation of a representation of a real entity, but not that entity itself. For example, when creating a flight plan, the pilot can be viewed as moving a fictitious aircraft through a fictitious airspace. The creation of the plan does not move the aircraft, but at some level of detail, this notional aircraft is behaving like a real aircraft. Notional representations can be purely mental, can be sketched on paper maps, or described textually. They can even exist within a computer program. The purpose of this distinction is to insure that the pilot knows when what he or she is doing will move the real aircraft or not. Notional displays usually have a lower tolerance for certainty than do actual displays. A storm can be predicted to intersect with a flight path; it may or may not actually happen. However the pilot is trained and conditioned to understand that notional information is not as certain and should be suspect.

(such as a spiral dive typical of loss of control accidents), and attempting to fly outside this envelope could be an event resulting in the emergency auto-land feature taking control of the airplane. Note: Boeing vs. Airbus design philosophy regarding the assumed level of pilot competence.

The system could provide the pilot with a warning that he is out of tolerance, and may want the airplane to take control.

Functional Architecture

Proposed Air Traffic and Flight Operations Event Sequences

Air Operations

Normal Operations

A super "wing leveler" may be activated by the pilot if disoriented, and will return the airplane to straight and level flight, after which the pilot may deactivate the autopilot and resume flight.

1. Pilot determines that he is disoriented in IMC conditions or because of vertigo, or not confident of his ability to remain under control in turbulence, and activates system.
2. System returns aircraft to straight and level flight.
3. Pilot deactivates when able.

System is always activated for envelope protection for an airplane performance limitation (e.g., Vne), and warns the pilot of impending exceedence

Senses aircraft operation outside performance envelope and limits pilot control to either prevent exceedence, or to make it very difficult. Since pilot can now overpower the autopilot servos (soft protection), this makes it very difficult to exceed the limitations, but retains the current philosophy of autopilot operation and keeps costs down by enabling the use of commercial autopilot servos.

Abnormal Operations Event Sequence

Opposing pilot commands improperly, causing an unsafe condition.

Emergency Auto-land

Summary of Emergency Auto-land Conops/Architecture

Description of New NAS capability.

Emergency Auto-land and Envelope Protection are designed to improve single-pilot small aircraft safety by avoiding a catastrophic failure effect in the event of pilot incapacitation or improper pilot maneuvering. The airborne systems required for these two capabilities are similar.

Emergency auto-land will safely land the airplane in the event of pilot incapacitation, allowing passengers to survive the landing, and in most cases saving the airframe. It can be initiated by the pilot or a passenger.

An emergency auto-land system will, when activated, find a suitable airport, set up for the proper approach, fly a published instrument approach, land the airplane, and stop the airplane on the runway. This system may be particularly useful for Part 135 single-pilot operations where passengers require the level of safety of a two-pilot-operation.

The system would not be activated by either the airplane or the ground for the following reasons.

There is a large cost and regulatory policy gap between a system than can only be activated by an airplane occupant and one that can be activated by the airplane itself or from the ground. The airplane could initiate this feature by establishing the pilot is no longer conscious through a query that is not answered, and where there are no passengers or the passengers fail to activate the system. In addition, the system could be initiated from the ground in the event of a airplane takeover. However, the use of this system for security purposes changes the basic philosophy of the system from cooperative to non-cooperative. For these reasons, in this SATS program, we will not address the non-cooperative initiation system. Activation by the airplane when the pilot does not respond to queries is only needed for safety reasons when the pilot is the only airplane occupant, but results in a large cost increase to implement safety. Therefore, since the probability of use is small compared to the cost of safe implementation, is it not attempted in this SATS program. Logically, the "activation/deactivation" system is differentiable from the autoland system, but they may share control logic and systems Note: B-777 has the feature that activates a lighted switch the pilot must activate if no control is touched in 10 minutes. We believe that if the single pilot is incapacitated, the benefits of saving the hull do not justify airplane activation of the system.

Therefore, airplane or controller activation may be recommended for examination in the follow-on SATS program.

The closest current baseline capability is a current Category IIIc approach, which are full auto-land, but they are initiated once established on an approach, rather than from cruise flight.

Differences between emergency and normal mode auto-land; emergency auto-land:

A. Non-hazard certification only (continued safe flight and landing not an issue).

B. Not need performance to land without aircraft damage in all wind conditions.

C. Not need highest availability or reliability (i.e., higher quality and dual thread sensors, computers, servos, etc.).

D. May also use it when need assistance (if fatigued) while monitoring its operation, if can easily over-ride.

E. Does not result in pilots becoming less able to land the airplane in gusty crosswind conditions through normal reliance on system for all landings.

F. More expensive system for all of the above reasons.

Similarities between emergency and normal mode auto-land.

1. Same control algorithms.

2. May have same servos (but just one).

Can use it as a higher quality coupled autopilot in approach mode while monitoring it.

Normal operations event sequence.

A. While en route, IFR or VFR, pilot who believes he is becoming incapacitated, or passenger activates system if the pilot is unconscious. The airplane can activiate the system through use of a "are you there switch" or low fuel exhaustion) activates system to protect interests of fellow shared ownership members if hypoxia or bird or hail through windshield), with protections against inadvertent activation.
B. Once activated, pilot can turn it off and resume control if no longer needed (e.g., descend to breathable altitude, recover from bird or hail trauma, or seizure), with protections against inadvertent cancellation.
C. Pilot can deactivate emergency calls if using it in assistance/monitoring mode only. Note: this could result in abuse, planned use for landings beyond the capability of the pilot and beyond performance, availability and integrity.
D. System locates nearest (or optimum) airport with adequate runways and approach equipment.
E. System activates 7700 squawk, 121.5 emergency voice synthesized mayday call and call out of destination, repeated call (which will serve to avoid IFR traffic), and also call on airport CTAF frequency.
F. Navigates around any severe weather using FIS.
G. Navigates around other traffic?? Or relies on other aircraft seeing and avoiding it.
H. Pilot can deactivate if no longer incapacitated.
I.Accomplish auto-land.
J. Apply brakes, shut down engine on runway.

Abnormal Operations event sequence

- Inadvertent operation.
- Abuse (pilot activation in non-emergency conditions, losing ability to land the airplane)

Functional Architecture (elements and functions)]

A. NAS elements None. B. Airborne Elements

- Sensors
- Servos
- Flight control system
- Navigation and airport data base
- Connection to transponder and radio for distress call
- Connection to throttle and brakes

4.5 CONCEPT SPS-E

(This is VA SATSLab ConOps Emergency Autoland)

Aircraft is equipped with automation that determines the nearest or best airport with a precision approach, builds a fight profile to the airport, and executes that flight profile to landing. The intent of the automation is for safe recovery of the occupants to an airport in the event of pilot incapacitation.

Introduction

Overview and Philosophy of Con OPS

Emergency Auto-land and Envelope Protection are designed to improve single-pilot small aircraft safety by avoiding a catastrophic failure effect in the event of pilot incapacitation or improper pilot maneuvering. The airborne systems required for these two capabilities are similar.

Emergency auto-land will safely land the airplane in the event of pilot incapacitation, allowing passengers to survive the landing, and in most cases saving the airframe. It can be initiated by the pilot or a passenger.

An emergency auto-land system will, when activated, find a suitable airport, set up for the proper approach, fly a published instrument approach, land the airplane, and stop the airplane on the runway. This system may be particularly useful for Part 135 single-pilot operations where passengers require the level of safety of a two-pilot-operation.

The system would not be activated by either the airplane or the ground for the following reasons.

There is a large cost and regulatory policy gap between a system than can only be activated by an airplane occupant and one that can be activated by the airplane itself or from the ground. The airplane could initiate this feature by establishing the pilot is no longer conscious through a query that is not answered, and where there are no passengers or the passengers fail to activate the system. In addition, the system could be initiated from the ground in the event of a airplane takeover. However, the use of this system for security purposes changes the basic philosophy of the system from cooperative to non-cooperative. For these reasons, in this SATS program, we will not address the non-cooperative initiation system. Activation by the airplane when the pilot does not respond to queries is only needed for safety reasons when the pilot is the only airplane occupant, but results in a large cost increase to implement safety. Therefore, since the probability of use is small compared to the cost of safe implementation, is it not attempted in this SATS program. Logically, the "activation/deactivation" system is differentiable from the autoland system, but they may share control logic and systems Note: B-777 has the feature that activates a lighted switch the pilot must activate if no control is touched in 10 minutes. We believe that if the single pilot is incapacitated, the benefits of saving the hull do not justify airplane activation of the system.

Therefore, airplane or controller activation may be recommended for examination in the follow-on SATS program.

The closest current baseline capability is a current Category IIIc approach, which are full auto-land, but they are initiated once established on an approach, rather than from cruise flight.

Differences between emergency and normal mode auto-land; emergency auto-land:

- Non-hazard certification only (continued safe flight and landing not an issue).
- Not need performance to land without aircraft damage in all wind conditions.
- Not need highest availability or reliability (i.e., higher quality and dual thread sensors, computers, servos, etc.).
- May also use it when need assistance (if fatigued) while monitoring its operation, if can

easily over-ride.

- Does not result in pilots becoming less able to land the airplane in gusty crosswind conditions through normal reliance on system for all landings.
- More expensive system for all of the above reasons.

Similarities between emergency and normal mode auto-land.

- Same control algorithms.
- May have same servos (but just one).

Can use it as a higher quality coupled autopilot in approach mode while monitoring it.

Functional Architecture

A. NAS elements

- None.

B. Airborne Elements

- Sensors
- Servos
- Flight control system
- Navigation and airport data base
- Connection to transponder and radio for distress call
- Connection to throttle and brakes

Proposed Air Traffic and Flight Operations Event Sequences

Air Operations

Normal Operations

- While en route, IFR or VFR, pilot who believes he is becoming incapacitated, or passenger activates system if the pilot is unconscious. The airplane can activiate the system through use of a “are you there switch” or low fuel exhaustion) activates system to protect interests of fellow shared ownership members if hypoxia or bird or hail through windshield), with protections against inadvertent activation.
- Once activated, pilot can turn it off and resume control if no longer needed (e.g., descend to breathable altitude, recover from bird or hail trauma, or seizure), with protections against inadvertent cancellation.
- Pilot can deactivate emergency calls if using it in assistance/monitoring mode only. Note: this could result in abuse, planned use for landings beyond the capability of the pilot and beyond performance, availability and integrity.
- System locates nearest (or optimum) airport with adequate runways and approach equipment.
- System activates 7700 squawk, 121.5 emergency voice synthesized mayday call and call out

of destination, repeated call (which will serve to avoid IFR traffic), and also call on airport CTAF frequency.

- Navigates around any severe weather using FIS.
- Navigates around other traffic?? Or relies on other aircraft seeing and avoiding it.
- Pilot can deactivate if no longer incapacitated.
- Accomplish auto-land.
- Apply brakes, shut down engine on runway.

Abnormal Operations Event Sequence

- Inadvertent operation.
- Abuse (pilot activation in non-emergency conditions, losing ability to land the airplane

4.6 Concept SPS-F

(This is Maryland SATSLab ConOps Emergency Autoland)

Description of concept of operations by phase of operation

Departure

Acquired from the SATS aircraft advanced technology processor and data base, the airport taxi diagram is automatically displayed, with actual position shown as well as preferred route to the takeoff runway position. By receiving and processing ADS-B signals and RF-tagged aircraft, vehicles and personnel other aircraft and ground vehicles are displayed on taxi diagram to help ensure against incursions. The SATS aircraft receives a takeoff time assignment at the time of flight plan approval from ATC, or via the airport digital data link. The SATS aircraft system displays enhanced vision of ground traffic during taxi operations to provide improved situational awareness. The SATS aircraft computer system monitors other airborne traffic positions and acquires available flight plan routes of nearby aircraft to construct a flight profile and path for merging with traffic flow. The onboard processor uses current and forecast weather, airport information and the pilot's flight plan to determine fuel, altitude and best routing for the flight event. The SATS aircraft computer system acquires from its data base and displays the flight path for standard instrument departure for that runway. Upon takeoff, the SATS aircraft system automatically notifies ATC via data link of the assigned departure time. As the SATS aircraft climbs, the computer system automatically enlarges scope of traffic display proportional to velocity, altitude, and flight phase. The SATS aircraft sensors provide enhanced vision of traffic and terrain along takeoff and departure path to ensure against CFIT and collision with other ground or flight objects. This is coupled with current on-board digital terrain data bases and "highway in the sky" navigation cues. This information together with route tolerances along the flight path is depicted on the primary flight display. The SATS aircraft system automatically notifies ATC upon arrival at requested reporting fix and provides position update. The computer system monitors traffic positions for conflict detection. The computer system provides guidance information to maintain self-separation from other flight objects, terrain, weather, and airspace boundaries. With other SATS aircraft on departure to the same departure fix, each is provided a sequence number based on information in their flight plans. The SATS aircraft computers collaborate to share status information and position information to maintain self-sequence and to respond properly in case of in-flight emergencies. In addition, the aircraft computer monitors conformance to the flight path and separation with other traffic, and alerts the pilot of any deviations with recommended corrective action.

En Route

The SATS aircraft computer system adjusts resolution and scale of display(s) appropriate to altitude and traffic density. The computer system conducts probes of its flight plan by accessing other flight plans that may intercept its course and violate its separation. It also acquires forecast weather information and airspace boundary status to determine if adjustments to flight plan are needed. The computer system identifies future potential conflicts with other aircraft flight paths and attempts to negotiate via data link with those SATS aircraft for route changes. The computer system advises the pilot of recommended flight plan adjustment (due to traffic or weather) and seeks acknowledgement for submission to ATC for approval. The computer system submits revised flight plan via data link to ATC for approval. The computer system automatically acknowledges receipt of flight plan revision or denial, and revises flight path accordingly.

The computer system continuously tracks suitable landing facilities en route in case of need for emergency landing to nearest airfield. It will anticipate transition to descent and approach by tracking traffic in the descent phase and constructs an insertion flight path into self-sequenced traffic. The computer system negotiates with other SATS aircraft via data link for assignment of a self-sequence position with other SATS aircraft. The computer system automatically acknowledges receipt of ATC clearance for approach, and reports time and position when departing controlled airspace to ATC via data link. All automatic actions of the SATS aircraft computer system require physical acknowledgement by the pilot.

In addition, an advanced processor and network system on the SATS aircraft will blend all static and dynamic information pertaining to aircraft system's health and status. Knowledge-based intelligent processing is performed by a special computer to oversee ATC instructions and pilot conformance to flight path and flight plan, as well as collaborate directly with ATC and other SATS aircraft via digital data link.

Descent and Arrival

The SATS aircraft computer system adjusts resolution and scale of display(s) appropriate to altitude and traffic density during the descent phase. The computer system presents checklist for pilot during descent for preparation for approach and landing. It monitors its self-sequence position with other SATS aircraft traffic on descent and in the pattern, and gives guidance instructions to pilot for maintaining sequence position while determining the most efficient and manageable flight profile based upon geography, arrival direction, traffic, weather and runway environment. The computer system monitors self-separation with other SATS aircraft, weather obstacles, airspace boundaries, terrain, and provides guidance instructions to maintain separation.

The computer system communicates via data link with the airport digital communication system (if available) for status on airport systems, local weather (AWOS), visibility, etc. If the airport has no communication system, local weather and visibility is automatically requested via data link from the weather service provider prior to approach clearance. The SATS aircraft's enhanced vision system provides look-ahead detection of non-reporting vehicles in the airspace and overlays targets on multi-function display (MFD) and/or primary flight display.

The computer system collaborates with other SATS aircraft on self-sequence position changes resulting from any aircraft's deviation from the assigned sequence. Acquired from current on-board data bases, the computer system displays the active standard instrument approach route (similar to a STAR) on the MFD with other transponding traffic, airspace boundaries, terrain, weather obstacles, etc. The computer system reports to ATC, via ground communications link if available, any change in estimated arrival time and sequence. The computer system adjusts display(s) resolution and scale for presentation of the approach path prior to arrival at the initial approach fix. It prompts the pilot for acknowledgement of checklist items at appropriate times during the descent and approach, and after landing.

Acquired from current on-board data bases, the computer system presents missed approach path and procedure if the pilot deviates beyond specified limits during the approach, avionics malfunction, runway out of service, traffic on runway, navaids out of service, visibility reduced beyond limits, etc., and the computer system notifies other SATS aircraft and ATC of change (if within communication range). The computer system collaborates with other SATS aircraft for insertion back into self-sequence position for approach, or into the departure sequence to transition to ATC for further guidance.

The computer system will provide approved alternative approach procedures (such as circular approach, curved approach, offset approach, steep glide paths, etc.) with couple guidance instructions to simplify maintaining course on the approach path. The SATS aircraft system provides enhanced vision of runway during final approach to ensure aircraft is clear of objects and vehicles. Ground based radio-frequency tagged vehicle positions are relayed via data link to the aircraft to provide additional assurance that the runway and taxiways are clear.

Upon landing, the computer system presents preferred taxi path on MFD with present position for exiting runway and guidance to terminal, FBO, hanger, etc. The computer system tracks position of all ADS-B transponding ground vehicles in relation to own position to mitigate incursions. The computer system automatically reports to all other SATS traffic and ATC via data link (if available) upon clearing the runway to closes the flight plan. SATS aircraft may act as communication nodes for other SATS aircraft for end-to-end data link communication with ATC. This is dependent on the proximity of SATS aircraft to one another and the ATC controlled airspace.

Mixed Equipage Operations

The SATS aircraft enhance vision sensors will provide look-ahead capability for detection of non-broadcasting aircraft and ground vehicles. Other SATS aircraft sensors will detect Mode-C transponding aircraft and identify the general bearing, range and altitude of the target. By continuously resolving the velocity vectors, the SATS aircraft will have the capability to resolve Mode-C transponding aircraft positions with sufficient accuracy to maintain separation in altitude, distance, and bearing. However, Mode-C aircraft will not be able to see or separate themselves from SATS aircrafts. Therefore, separation algorithms in the SATS aircraft computer will calculate and display larger separation assurance areas for Mode-C aircraft. These areas may vary in volume over time depending on the geometric relationship of the Mode-C and SATS aircraft. Collaborated results of detected Mode-C aircraft by multiple SATS aircraft via data link may improve resolution of position information which can be shared by all SATS aircraft in the airport's airspace.

Non-Normal Operations

The SATS aircraft computer system calculates and presents flight path for returning to airfield upon emergency. When the pilot declares emergency, the computer system automatically notifies ATC and other SATS aircraft of status and position. For emergency return to airport, the computer system negotiates with other SATS aircraft in descent/approach phase for highest priority in sequence for landing.

Rare-Normal Operations

SATS aircraft will have data link access to digital weather forecasts. In addition, SATS aircraft will automatically collect weather sensor data in-flight, and distribute the data to the NWS. Sensors on the SATS aircraft will also observe lightning strike incidents in localized severe weather cells and the computer system will create a composite weather picture with other data for display to the pilot. Convective weather at the airport may be detected by local AWOS and superimposed by the aircraft computer on the pilot's display. The SATS aircraft computer will automatically calculate and display graphic separation criteria for pilot to maintain clear of severe weather cells.

ATC guidance instructions during en route for separation with other traffic, weather obstacles, terrain, man-made obstructions, and airspace boundaries will be automatically input into the SATS aircraft computer system. Monitoring of ATC instructions with on-board sensors and data basses will confirm separation assurance and thereby reduce the potential for ATC human errors to propagate into incidents or accidents.

SATS aircraft enhanced vision sensors will improve the pilot's ability to locate non-transponding aircraft when operating in non-radar airport airspace.

Similarly, the on-board SATS computers will monitor pilot flight performance in regard to conformance to flight path and altitude, separation from system identified obstructions (including airspace boundaries and other traffic and weather). Checklists will automatically be generated by the SATS computer in anticipation of flight plan maneuvers. Certain actions will be performed by the computer to relieve cockpit workload, such as checking weather conditions at the destination airport, and identify other alternate airports with acceptable minimums and modify flight plan for review and submission by the pilot. Another example may include automatically locating and displaying the correct approach plate and displaying a flight path from the present position to the IAF. These capabilities will serve to assess flight path conformance, anticipate next step actions, perform redundant duties, and thereby, reduce the potential for pilot-induced errors.

4.7 CONCEPT SPS-G

(This is Southeast SATSLab ConOps)

INTRODUCTION

Overview and general philosophy of the CONOPS

Hypothesis: Single private pilots with instrument ratings can reliably fly modern aircraft at skill and safety levels currently associated with ATP rated pilots through implementation of airborne and ground based training, avionics and CNS/ATM technologies, coupled with improved flight operations procedures, under CAT I IMC conditions.

Initial experiment activities will include baselining the human performance of candidate SATS pilots. We plan to accomplish this by measuring flight path management precision in terminal and enroute flight operations against the FAA criteria for private pilots with Instrument Ratings and for ATP-rated pilots. We will also assess situational awareness and pilot workload, both of which are known to be factors in safe flight operations. We are also looking into the current performance baseline of the current (2000) NAS, and of current aircraft of appropriate kinds to provide insight not only into the human performance but that of the entire system. We believe that through a combination of improved avionics, controls, aircraft and ground systems reliability, training, and flight operations procedures, we will achieve mission reliability and safety comparable to that of commercial air travel.

The SPP project will consist of a series of experiments and demonstrations that show how enabling technologies and innovative procedures can improve on single pilot performance during IMC.

We plan to baseline current single crew performance in conventionally equipped aircraft during ILS approaches and cross country line of flight training (LOFT) flights using flight data recorders and ground infrastructure to understand the state of performance in the NAS today. This is a criterion-based study against the FAA Practical Test Standards for ATP rating. We will also baseline the current NAS and avionics systems to understand the total system performance for the year 2000. We will then explore performance changes brought about by improvements in flight controls and displays, and accuracy and timeliness of Navigation, Surveillance, and Weather information to the single pilot in advanced technology aircraft. We plan to show that single pilots with instrument ratings, qualified in the respective aircraft, and with median flight experience can fly to ATP standards using the new avionics and procedures.

We plan to examine the workload reduction benefits provided by advanced cockpit automation, communications, control and display systems of e. g. information acquisition, enroute flight plan amendments, hazardous weather, conflict , and system anomaly alerts, adevisories, pilot response and resolution, and relatively complex transition and landing maneuvers, including automatic in-trail separation, automatic RTA acquisition, and perhaps emergency autoland, if we are convinced that it can be safely evaluated, afforded by systems such as the Harris Airborne Internet, Goodrich SmartDeck, Avidyne HiTS displays, Collins and ERAU collaborative sequencing and conflict management algorithms, and Raytheon decoupled control system.

All flight experiments will be simulated prior to flight, and safety pilots will be utilized. We will simulate Category I IMC conditions (200 feet & 2400 feet).

Definition of Terms

Changes From Current Operations, Procedures, or Policies

Specific simulations and experimental flights planned include:

- Baseline ILS approaches (Standard FAA-approved) in VMC under simulated IMC – Subject pilots fly standard ILS approach "under the hood" with SAFTPIC. Aircraft position data vs. ATP PTS requirements is recorded. Flight data are analyzed to determine pilot performance. A typical baseline flight approach scenario starts in the air, with the subject pilot requesting an ILS approach from the MOCC. The winds at the destination airport will be measured will be measured either by an onsite ASOS or the ACTT, and if the crosswind component is within the prescribed tolerance, and all other conditions are favorable, the approach will be approved for measurement. If conditions are unfavorable, the request will be denied and the subject pilot will either go around, or suspend experimental flight until winds subside. Once approved, the subject pilot will fly the approach to 2400 feet from touchdown and 200 feet AGL, the reference decision height, and then execute a missed approach, a touch-and-go, or a full stop landing.

- New Technology SATS Approaches in VMC under simulated IMC - Subject pilot flies SATS approach "under the hood" with SAFTPIC. Aircraft position data vs. ATP PTS requirements is recorded.

- Baseline Cross-Country Flight Path Management and Situational Awareness with conventional avionics (LOFT) – Subject pilot flies LOFT mission "under the hood" with SAFTPIC; Aircraft position vs. time is recorded for conformance to flight plan. Weather, Restricted airspace, secondary workload tasks, and traffic events are programmed into scenario. SAFTPIC is CFI who evaluates subject pilot performance as if experiment flight were ATP check ride. Baseline LOFT flights will begin at an originating airport, with the normal preflight checks. The subject pilot will depart the originating airport and fly an approved LOFT flight plan. If the LOFT flight plan includes controlled airspace, the flight plan will have been filed and approved prior to launch, and the subject pilot will communicate normally with ATC. During the flight, the subject pilot will be presented with traffic events, restricted airspace, secondary workload tasks, and Hazardous Weather advisories to which (s)he must appropriately respond. The SAFTPIC will evaluate the subject's performance with respect to ATP performance.

- New Technology SATS Cross-Country Flight Path Management and Situational Awareness (LOFT) - Subject pilot flies LOFT mission "under the hood" utilizing SmartDeck or other HITS/MFD avionics, with SAFTPIC; Aircraft position vs. time is recorded for conformance to flight plan. Weather, Restricted airspace, secondary workload tasks, and traffic events are programmed into scenario. SAFTPIC is CFI who evaluates subject pilot performance as if experiment flight were ATP check ride. SATS LOFT flights will begin at an originating airport, with the normal preflight checks. The subject pilot will depart the originating airport and fly an approved LOFT flight plan under simulated IMC (under-the-hood). If the LOFT flight plan includes controlled airspace, the flight plan will have been filed and approved prior to launch, and the subject pilot will communicate normally with ATC. During the flight, the subject pilot will be presented with traffic events, restricted airspace, secondary workload tasks, and Hazardous Weather advisories to which (s)he must appropriately respond. The SAFTPIC will evaluate the subject's performance with respect to ATP performance.
- LLM & HVO approach operations with advanced aircraft technologies – Subject pilot performs LLM and HVO operations with successively more advanced cockpit capabilities (SVS, EVS, Advanced Controls, CSEQ, CD&R) to determine the benefits of advanced controls and displays on pilot performance.

Key Assumptions

1. Pilots and ground segment possess valid and timely information about ownship and other aircraft, terrain, obstacle, hazardous weather object, approach path, and runway position, and velocity.
2. Pilots possess knowledge of missed approach procedures.

DESCRIPTION OF CONCEPT OF OPERATIONS BY PHASE OF FLIGHT

Departure Phase

Departure will only be considered for the integrated experiment and demonstration missions. For the 2003POCX, we will limit our experiments to those activities conducted underway in terminal airspace and occasionally in enroute airspace.

En Route Operations

Enroute operations will be limited to LOFT flights for SPP, and integrated experiments and demonstrations. During these flights, subject pilots will conduct SPP LOFT flights in conventional and advanced display-equipped aircraft to determine differences in flightpath management, situational awareness, and judgment skills. These flights will include traffic events and distractor tasks to challenge the pilot.

Simulated SATS missions conducted as part of integrated experiments and demonstrations will include flights of 300-1000 miles and will incorporate typical SATS enroute and approach and landing procedures.

CFI SafTPICs will assure safe operations throughout, and will evaluate subjective aspects of pilot performance. Details of flight conditions are contained in the FTOSR.

Descent and Arrival

The majority of our experiment flights will concentrate on HVO and LLM approach activity. During these flights, subject pilots will conduct baseline ILS approaches, SATS LLM approaches, and SATS HVO approaches under simulated IMC in coordination with the SOCC or MOCC, to precoordinated flight plans. SafTPICs will assure safe operations throughout. Details of flight conditions are contained in the FTOSR.

Mixed equipage operations

Mixed equipage operations will generally only occur during VMC, during marginal IMC, or at airports equipped with ILSs. We will explore detection and integration of aircraft that are not ADS-B equipped by using FAA radar feeds for Mode C transponder-equipped aircraft, and the small airport radar transceiver (SmART) for Mode C intruders. The latter will be primarily for safety purposes as a mitigation of runway incursions or airborne conflict threats, since such aircraft should not be operating under IMC. SafTPICs will assure safe operations throughout. Details of flight conditions are contained in the FTOSR.

Non-Normal

IN-FLIGHT EMERGENCY

Communication failure

Datalink – ADS-B capabilities lost; Pilot will revert to normal IFR flight and divert to an ILS-equipped airport;

Voice – Pilot will revert to standard Communications Failure procedures;

Navigation system failure –

GPS – Pilot will revert to normal IFR flight and divert to an ILS-equipped airport ;

WAAS – Pilot can continue SATS flight if WLIM is functioning ;

WLIM - Pilot will revert to normal IFR flight and divert to an ILS-equipped airport ;

Surveillance failure

ADS-B – Pilot will revert to normal IFR flight and divert to an ILS-equipped airport ;

Small Airport Radar – Pilot will revert to normal IFR flight and divert to an ILS-equipped airport ;

Rare-Normal Operations

Adverse weather

Hazardous Wx advisories will be presented to the SATS pilot, along with the capability to amend the flight plan to avoid hazardous weather events. This capability utilizes the Weather and flight plan graphics display on the MFD, and the avionics GUI to allow the pilot to transmit the amended flight plan to the cognizant AFSS for approval. Once the flight plan amendment has been approved and acknowledged by the pilot, the HiTS pathway is adjusted to the new flight plan and the pilot continues the flight.

Human error (e.g. pilot and any controller)

We have no specific plans to explore the wide range of potential human error in flight operations beyond documenting events that occur during our experimental flights and demonstrations and analyzing those events that are attributable to human error from a human factors standpoint to be able to mitigate further occurrences.

Some protection capabilities are inherent in the advanced display and control suites. For example, if a pilot should fly outside of the flight plan pathway, the Goodrich SmartDeck provides a "Pathway Reacquire" function that the pilot can execute to efficiently return to the flight plan. Further, the Raytheon advanced controls system provides some protection against the pilot commanding the aircraft beyond its performance envelope.

With respect to ATC controller human error, our philosophy is one of avoidance of the NAS by SATS flights except as necessary to comply with controlled airspace regulations. We believe that the additional information provided to the pilot regarding weather, traffic, and terrain/obstacles, will significantly reduce the probability of accidents and incidents with SATS flights.

5.0 CONCEPTS OF OPERATIONS FOR EN ROUTE

5.1 CONCEPT ER-A

(This is VA SATSLab 4-D Flight Path Control)

Aircraft is equipped with automation (algorithms) that provide guidance as to route and speed to arrive at a fix at a precise altitude and time for compliance with 4-D flight path clearances.

5.2 CONCEPT ER-B

(This is Maryland Mid-Atlantic SATSlab conops)

Description of concept of operations by phase of operation

Departure – Not applicable.

En Route

During IMC and under radar coverage, en route operations conform to air traffic control guidance, rules and procedures. Separation will be maintained by ATC. SATS aircraft will operate and interface with ATC in the same manner as every other IFR aircraft. This includes the capability to fly direct-to "free flight" routes or to conform to standard airway routes. Navigation via GPS WAAS is expected to provide to necessary accuracy, reliability, and availability of service. During VMC, SATS aircraft will comply with the existing procedures for see-and-avoid to maintain separation from other traffic.

With enabling sensors and algorithms, SATS aircraft will monitor other transponding aircraft positions on a situation display and have the capability to automatically resolve conflicts and maintain separation with other aircraft, weather obstacles, airspace boundaries, terrain, and man-made obstructions. SATS aircraft will have the capability to automatically data link their updated positions in-flight to ATC in order to update their flight plans, and to predict traffic flow density and impact on adjacent sectors and terminal areas. Such real-time information will facilitate greater accuracy in optimizing terminal airspace and en route traffic flows. SATS aircraft will have the capability to relay position and flight plan information to ATC from other SATS aircraft transitioning to radar coverage and controlled airspace (airborne internet mode).

Real-time weather information gathered from on-board SATS aircraft sensors will relay environmental data to the NWS for a more accurate NAS weather composite. SATS aircraft traversing en route over a general aviation airport with a data link transceiver and a digital interface to the NAS-wide Information Center (NIS) will be able to send and receive updated flight plans, FIS, TIS and CIS information for destination and alternate airports. This service should encourage free-flight operations among general aviation airports catering to SATS aircraft, thereby reducing disruptions to NAS traffic flow in more congested terminal areas and airspace sectors. It is expected that many general aviation airports, particularly along the east coast, will accommodate traffic that operates adjacent to existing sectors and TRACONs. The NIS will be better able to calculate traffic flow projections and dynamic traffic density for sectors and TRACONs by having up-to-date traffic positions and flight plans of SATS aircraft via these general aviation airport digital interfaces to the NIS.

In addition, an advanced processor and network system on the SATS aircraft will blend all static and dynamic information pertaining to aircraft system's health and status. Knowledge-based intelligent processing is performed by a special computer to oversee ATC instructions and pilot conformance to flight path and flight plan, as well as collaborate directly with ATC and other

SATS aircraft via digital data link.

Descent and Arrival – Not applicable.

Mixed Equipage Operations

During VMC, standard see-and-avoid flight rules will be followed for traffic separation assurance. During IMC, SATS vehicles will receive ADS-B position and intent information and Mode-C transponder position information through enabling technology sensors and algorithms. The Mode-C will yield much less accurate position information, but will nonetheless alert the pilot of traffic and provide general bearing, altitude, and range information. Position, orientation, and path of traffic will appear on a traffic situation display in the cockpit. Resolution of data will depend on the source and will be so noted on the display. Separation assurance algorithms will calculate separation zones based on the target and source of its position data. Less resolvable position targets will result in larger separation distances. Collaborated results of detected Mode-C aircraft by multiple SATS aircraft via data link may improve resolution of position information which can be shared by all SATS aircraft in the airport's airspace.

When not under radar controlled airspace, self-separation will be provided by the SATS aircraft's algorithms; however, any deviation from ATC instructions will be reported to ATC. While under ATC radar control, the SATS aircraft self-separation algorithms will provide an added margin of safety; however, the SATS aircraft will conform to ATC separation instructions unless an ATC human error is encountered.

Non-Normal Operations

SATS aircraft will conform to standard flight rules and procedures for in-flight emergencies and CNS avionics failures. During en route operations, ATC will provide direct assistance if voice communication is functional. ATC may use data link communication for guidance and instructions if only voice communication has failed. ATC will be able to monitor Mode-S transponders of SATS aircraft for position and ensure safe separation from other aircraft.

The on-board SATS computer will monitor dynamic and static aircraft systems to continuously assess aircraft health parameters. With predictive algorithms, some aircraft system failures can be averted through timely maintenance actions or by modifying the use of aircraft systems while in flight. The potential for encountering in-flight emergencies due to system failures may be significantly reduced in this manner.

Rare-Normal Operations

SATS aircraft will have data link access to digital weather information and forecasts. In addition, SATS aircraft will collect weather sensor data in flight and distribute the data to the NWS. Adverse weather objects in the en route environment will be observable both in the cockpit and by ATC. ATC will be responsible for separation from known weather obstacles.

Sensors on the SATS aircraft will also observe lightning strike incidents in localized severe weather cells that may not be observable by ATC. Convective weather at lower en route altitudes may be detected by AWOS at general aviation airports and reported to NWS to create weather composites. Higher altitude clear air turbulence (CAT) will be more difficult to detect in advance, but SATS aircraft encountering CAT will automatically report incidents of turbulence to the NWS and ATC.

ATC guidance instructions for separation with other traffic, weather obstacles, terrain, man-made obstructions, and airspace boundaries will be automatically input into the SATS aircraft fight management system. Monitoring of ATC instructions with on-board sensors and data bases will confirm separation assurance and thereby reduce the potential for ATC human errors to propagate into incidents or accidents. During VMC, the pilot will still be required to have situational awareness through see-and-avoid flight rules. SATS aircraft enhanced vision sensors will improve the pilot's ability to locate non-transponding aircraft when outside of primary radar coverage in VMC ATC controlled airspace.

Similarly, the on-board SATS computers will monitor pilot flight performance in regard to conformance to flight path and altitude and separation from system identified obstructions (including airspace boundaries, other traffic, and weather). Checklists will automatically be generated by the SATS computer in anticipation of flight plan maneuvers. Certain actions will be performed by the computer to relieve cockpit workload, such as checking destination weather for the future ETA, identifying other alternate airports with acceptable minimums, and modifying flight plans for review and submission by the pilot. Another example may include checking the status of special use airspace for a more direct route and modifying the flight plan appropriately. These capabilities will serve to assess pilot flight performance (to increase separation area buffer as a consequence of fatigue or aircraft handling difficulty, but not for reporting to ATC), anticipate next step actions, perform redundant duties, and thereby reduce the potential for pilot-induced errors.

5.3 CONCEPT ER-C

(This is Southeast SATSlab conops)

INTRODUCTION

Overview and general philosophy of the CONOPS

Hypothesis: Significant numbers of SATS flights can be safely conducted within the NAS without adversely impacting delays, conflicts, or ATC controller workload.

We do not plan any flight experiments during this phase of the SATS program to prove concepts for or demonstrate enroute integration with the NAS. We have conducted two rounds of modeling and have concluded that there is no immediate threat of difficulties with SATS enroute integration with the NAS. We have examined a central Florida executive airport in close proximity to Orland International Airport, a busy commercial terminal (SATS Precursor Studies, User Needs, Speed and Capacity, 1999), and we have examined small airports in the vicinity of the ten busiest airports in the nation (SATS CTN System Analysis). We have introduced up to 200 daily SATS flights into the airspace (transition sectors) and have not found significant increases of conflicts, delays, or ATC workload. We believe that it will be many years before the SATS fleet grows to the point that these levels of flight activity will be achieved, and that the NAS capability will grow to safely accommodate the needs.

We expect that the mission scenarios flown in support of the other operational capabilities may confirm these findings, and data gathered during those flights will be analyzed to see if they confirm our analytical results.

The ERI Project will consist primarily of SATS traffic modeling in representative ATC sectors of various types expected to be encountered in SATS missions. Extending the analytical work accomplished during the 1999 User Needs studies for Speed and Capacity, we have continued to utilize the Total Airspace and Airport Modeler (TAAM) to examine the effects of between 0 and 200 additional SATS aircraft per day in representative ATC sectors. We will be examining the effects on delays, conflicts, and ATC controller workload. We can exercise TAAM with records of existing traffic from the FAAs Enhanced Traffic Management System (ETMS), along with the varied additional SATS flights. We can also explore the effects of weather events or GPS anomalies causing diversions of SATS flights.

During the CTN, we have already modeled SATS traffic in the transition sectors for small GA airports near the ten busiest commercial hub airports in the nation. Consistent with the results we got in the User Needs Precursor study for speed and capacity in 1999, we found no significant impact on current delays, conflicts or controller workload when up to 200 SATS flights were added to current traffic.

Key Assumptions

1. There will be no drastic changes in current personal or small business aircraft production or pilot training capabilities within the next five years.
2. There will be no drastic changes in FAA regulatory procedures within the next five years.

5.4 Concept ER-D

(This is Virginia SATSlab Conops ERO-1)

Introduction

Overview and Philosophy of Con OPS

The objective of this Con Ops is to increase the capacity of the En Route Airspace to accommodate increased demand generated by SATS. A separate SATS airspace is defined at the under utilized flight low altitude sectors between FL130 and FL180, and the high altitude sectors between FL350 and FL410. All aircraft entering the airspace must be appropriately equipped since controller intervention is only for emergencies.

- Create autonomous operations airspace (Class FF – Free Flight) from 13,000 feet to 18,000 feet, with initial separation of 1,000 ft vertical and 8.6 nmi horizontal (i.e. ~90 seconds separation at 360 knots closing speed). SATS aircraft do not need controller intervention other than in exceptional circumstances such as declared emergencies.

- Low cost domestic RVSM capability from FL130 to FL180 in Class FF airspace, reducing separation from 1000 ft to 500ft would double the SATS operational densities within this region to ~ 120,000 flight operations per hour. Approximately 2000 SATS airports within this region (at 1 runway each and 30 arrivals per hour capability) would be required to operate at this flight density.
- Create cruise corridors of Class FF, with cruise clearance and self-separation, and need clearance to cross the corridor for non-equipped aircraft.
- Create offset GPS routes parallel to airways, including GPS defined routes, for increased safety and capacity. (Get 8 times the traffic flow using 1-mile track separations within an airway).
- Enable groups of aircraft, each self-separating through station keeping, to be handled as one unit by controllers.
- Create outlying airport arrival/departure corridors to avoid congesting terminal areas with creased operations into nearby small airports.
- Create transition areas between FF and conventional controlled airspace.

This ConOps interfaces with the HVO and LLM ConOps at the En Route transition point.

Definition of Terms

Changes from Current ConOps, Procedures, or Policies

Changes in Air Traffic Procedures

Re-design of low altitude route structure to accommodate SATS corridors. Possible reduced vertical separation (RVSM) within the confines of SATS corridors.

Changes in Flight Operations Procedures

Self-separation in en route airspace designated for SATS users.

Air Traffic Services

Flight Planning

Automated flight planning support may be required at non-towered airports.

ATC Separation

New rules may be required to accommodate SATS-specific separation standards within en route corridors in which self-separation and station keeping algorithms are utilized.

Advisory

Weather

No change to current or forecast systems.

Traffic

Traffic advisories pertinent to whether or not a SATS en route corridor has been activated, much as military operating areas and VR/IR routes are in effect today.

NAS Status

Availability of en route corridors and possible "reservations" in view of (prospective saturation) may be required as part of an automated flight planning process.

Strategic Flow

National level strategic flow should be unaffected.

Synchronization

Airborne Traffic

NAS Reconfiguration – a traffic management (TM) initiative involving reconfiguration of NAS elements within a sector or region to accommodate surges in demand.

Demand Modulation – a traffic management initiative when NAS reconfiguration is not feasible. Usually involves a time-based or trajectory-based solution to excess demand. See ATS ConOps Addendum 1, Part 3.1.4.3.

Ground Traffic

Not applicable, except at the national level for strategic flow of high traffic density airports.

Navigation

Satellite navigation (GPS with WAAS) is primary navigation method.

Airspace Management

Introducing new airspace structure (corridors, displaced routes) will require significant change to navigation publications, as well as the techniques used by ATC to manage aircraft utilizing (or avoiding) the new structure.

Emergency and Alerting

No change.

Airport Management

Not applicable.

Certification Services

Aircraft Certification

No change.

Flight Standards

No change.

Key Assumptions

- All separation and sequencing services provided by an ARTCC with low altitude radar coverage will be provided by SATS Conops/Architecture sufficient to handle subject performance level with no, or virtually no, controller involvement to avoid increasing FAA costs.
- Mixed-equipage must be permitted, without denying access to current VFR or IFR aircraft or pilots. When voluntary equipage rates reach a high level, FAA may then require the remaining small percentage of non-equipped aircraft to equip or lose access to certain airspace.
- All aircraft prior to and within an en route "corridor" would be on the same voice frequency, either with ATC or a synthesized voice or CTAF frequency.
- Assume no constraints on speed differentials.

Functional Architecture

Proposed Air Traffic and Flight Operations Event Sequences

Air Operations

Only en route operations are addressed. By the nature of this CONOPS, no arrival, departure, or ground operations are appropriate. However, multiple techniques are offered, each designed to present a unique solution to increase capacity in under-utilized airspace.

Normal Operations En route operations (Cruise Corridors)

- Pilot has filed for a cruise corridor that connects terminal airspace from departure airport with terminal airspace of destination airport.
- Aircraft arrives at departure clearance limit (fix?) at altitude assigned, in radio contact with ATC.
- Pilot requests clearance to enter "cruise corridor" and willingness to accept "electronic separation".
- ATC "activates" cruise corridor (if not already in use) and re-routes non-participating aircraft around (above or below) the airspace volume.
- ATC advises pilot of other traffic within the corridor boundary and direction of flight. Corridor may be one-directional, or have single-directional altitude "blocks".
- Pilot acknowledges traffic and confirms through TIS-B (or other display) that he/she has an electronic "visual".
- ATC updates clearance and notifies pilot to remain within the confines of the cruise corridor altitude block of 13,000 – 18,000 ft MSL, and some width dimension (10 NM?) not unlike military VR or IR routes.
- ATC authorizes frequency change (to cruise corridor "common frequency"), assigns an appropriate squawk, and provides an exit "fix", time, and frequency assignment to contact ATC at the exit point.

- Pilot complies with clearance as assigned and adjusts route to maintain separation while adjusting speed to arrive at exit point at assigned time.
- Prior to arrival at exit fix, pilot contacts ATC on previously assigned frequency for further clearance into terminal airspace using HVO techniques.

Rare Normal Operations

Adverse Weather

Pilot can maneuver within the confines of the corridor to avoid adverse weather. For deviations outside the corridor, contact ATC and request a deviation.

Traffic in excess of capacity

ATC controls traffic volume into or from a cruise corridor at fixed points and intersections. Traffic volume is limited based on size of altitude block, corridor width, and any limitations on directional flow.

Pilot Errors

Pilot inadvertently exits cruise corridor. ATC notifies on common emergency frequency.

Controller Errors

Controller fails to activate cruise corridor and separate from other IFR traffic. See and avoid rules apply. For IMC, pilots that are ADS-B equipped can detect intrusion and avoid in cruise corridor.

Abnormal Operations

System Failures

Loss of Communications

- Pilot squawks 7600 and continues to destination within cruise corridor.
- Pilot complies with lost communications procedures outlined in AIM.

Loss of Navigation

Pilot requests assistance from ATC. ATC issues vectors or other instructions to clear cruise corridor and proceed to a suitable destination.

Loss of Surveillance

If loss of surveillance precludes self-separation, pilot notifies ATC. If problem is “system-wide”, cruise corridor clearances are canceled and traditional ATC control is imposed. Traffic volumes decrease.

Loss of Weather information

No impact.

Loss of Flight Information

If loss of flight information precludes self-separation, pilot notifies ATC. ATC issues instructions to exit and clear cruise corridor and provides traditional route and altitude clearance.

Loss of Automation

Loss of automation may preclude clearances using RVSM or other precision techniques or technologies. If a technology-driven clearance is in effect and automation is lost, ATC must revert to back-up separation, sequencing rules and amend clearances accordingly.

Deliberate Pilot Misuse

Pilot accepts clearance without required equipage or system availability.

Security Emergency

No discernible catastrophic event while in en route airspace. Significant deviations from flight plan, aberrant behavior, should result in alert to prospective "destinations" (such as nuclear power plants or population centers) at which damage could occur.

En route operations (Groups, self-separating as an electronic "formation")

Normal Operations

- Pilot has filed a route of flight that contains commonly utilized route segments defined by particular "end points" identified by NAVAIDS or other means.
- Aircraft arrives at "end point" at altitude assigned, in radio contact with ATC.
- ATC has multiple aircraft converging on the "end point" with the same segment on their flight plan.
- ATC advises pilots of all traffic with the common segment that they can be cleared as a group, provided that the participants have electronic separation capability.
- Pilots acknowledge traffic and confirm through TIS-B (or other display) that he/she has an electronic "visual".
- ATC assigns a "lead" aircraft, behind which all others must maintain separation standards.
- ATC provides common clearance to all participants, assigns a common frequency, discrete squawks, and instructs them to maintain electronic separation until arrival at the end of the common route segment.
- Pilots comply with clearance as assigned and utilize on-board equipment for station-keeping.
- Prior to arrival at exit fix, pilots contact ATC for further clearance into terminal airspace or continuation on en route structure.

Rare Normal Operations

Adverse Weather
Pilots can maneuver to avoid adverse weather while maintaining adequate separation. For deviations outside the route of flight, lead aircraft contacts ATC and request a deviation.

Traffic in excess of capacity

ATC controls traffic volume into or from a route segment at fixed points. Group clearances are a means of increasing capacity.

Pilot Errors

Pilot violates separation standard. Other aircraft receive warning based on collective responsibility for separation.

Controller Errors

Abnormal Operations

System Failures

Loss of Communications

Pilot squawks 7600 and continues to destination. Pilot complies with lost communications procedures outlined in AIM.

Loss of Navigation

Pilot requests assistance from ATC. ATC issues vectors or other instructions to clear route segment, relieve responsibility for self-separation, and proceed to a suitable destination.

Loss of Surveillance

If loss of surveillance precludes self-separation, pilot notifies ATC. If problem is “system-wide”, electronic separation clearances are canceled and traditional ATC control is imposed. Traffic volumes decreases.

Loss of Weather information

No impact. However, multiple aircraft on a common frequency can compensate for a single aircraft loss of weather situation awareness.

Loss of Flight Information

If loss of flight information precludes self-separation, pilot notifies ATC. ATC issues instructions to exit route segment and provides traditional route and altitude clearance.

Loss of Automation

Loss of automation may preclude clearances using RVSM or other precision techniques or technologies. If a technology-driven clearance is in effect and automation is lost, ATC must revert to back-up separation, sequencing rules and adjust clearances accordingly.

Deliberate Pilot Misuse

Pilot accepts clearance without required equipage or system availability.

Security Emergency

No discernible catastrophic event while in en route airspace. Significant deviations from flight plan, aberrant behavior, should result in alert to prospective "destinations" (such as nuclear power plants or population centers) at which damage could occur.

Interaction with other Planned Conops/Architectures Must be consistent with all HVO CONOPS in terms of the physical and procedural interface with terminal airspace.

APPENDIX A: Baseline operational Concept for 2005 Technology Demonstration

Appendix A of this document contains the baseline operational concept for the 2005 technology demonstration. The baseline operational concept was jointly defined by NASA and NCAM to represent functionality that can conservatively be expected to be developed to TRL-6, evaluated in integrated flight evaluation, and included in the 2005 technology flight demonstration within the budget, schedule, and staffing of the SATS program. The baseline operational concept will be periodically revised during the program to incorporate results of studies and analyses, but will be frozen at the beginning of the Demonstration and Closeout phase of the program.

INTRODUCTION

The Small Aircraft Transportation System (SATS) has been proposed as a new way for people and goods to be transported in the near future. The SATS Alliance members have been engaged in fostering SATS for several years, through participation in various aviation research programs including the Advanced General Aviation Transport Experiment (AGATE), the Aviation Safety Program, Safe Flight 21, HeliStar, Capstone, and other aviation mobility initiatives.

In order to advance the SATS concept, we are now engaged in regional efforts to show the residents, businesses, and state governments that there is a better way to travel than current alternatives available to many of those people who wish to travel or to move goods over distances of up to 1000 miles.

Concurrent with that regional effort, the Alliance is participating with other state and regional teams to accelerate a common understanding among the federal government, state governments, state and regional aviation authorities, and the general public, of what SATS can be – a significant new transportation alternative, and an economic development program for a large portion of the nation's populace.

As part of the technical groundwork needed to prove the viability of the SATS approach, a concept of operations, or ConOps, is being developed. This appendix represents the baseline aggregated approach to reaching goals established for each of the four operational capabilities documented in the SATS Program Plan:

Definition of Terms

Acronyms used herein will be repeated throughout the four operational capability sections without further explanation.

- Global Positioning System (GPS)

- Cockpit Display of Traffic Information (CDTI)
- Airborne Data Link Communication – To provide for digital voice and data communication to ATC and to the airport digital communication server.
- Synthetic Vision System (SVS): An on-aircraft system that provides the capability to for the pilot to see a virtual image of the terrain and obstacles near his aircraft
- Enhanced Vision System (EVS): An on-aircraft system that provides the capability for the pilot to "see through" low visibility conditions caused by low (or no) light, e.g., night, and weather conditions, e.g., fog, clouds or rain
- Conflict Detection and Resolution (CD&R) and Collaborative Sequencing (CSEQ) based upon ADS-B messaging. These capabilities will be applied through ground processing, and migrate to airborne processing.
- Self-Controlled Area (SCA) - An area (normally surrounding a non-towered airport) designated for high volume operations.

HIGH VOLUME OPERATIONS

H 1.0 **Introduction**

H 1.1 Overview

H 1.1.1 Automated sequencing (ASEQ) (incorporating considerations of traffic, weather, airspace and other local restrictions, aircraft performance, and pilot preference), and conflict detection and resolution (CD&R) capabilities, combined with procedural changes that allow for "electronic separation", should significantly increase throughput at non-towered, non-radar airports without additional demand on terminal controllers.

H 1.1.2 An area of flight operations called the Self-Controlled Area (SCA) will be established around each non-towered, non-radar airport designated for high-volume operations. Inside the SCA, appropriately trained pilots with HVO-equipped aircraft are responsible for maintaining separation from other aircraft. Before entering the SCA, the pilot must establish communications with the SATS automation. For flights entering self-controlled areas from traditional positive-controlled airspace, controllers transfer separation authority to pilots. This transfer of separation authority is similar to pilots accepting responsibility for separation on visual approaches under IFR.

H 1.1.3 SATS sequencing operations will increase small airport capacity during instrument meteorological conditions. Sequencing technologies and procedures will be developed during the program as a hybrid approach consisting of both in-trail and Required-Time-of-Arrival (RTA) operations:

- In-Trail Operations – Pilots requesting approach to a runway will be assigned an aircraft to follow, or sequence number, and an approach path from a predefined set, with instructions to maintain separation from the previous aircraft in the sequence. Separation criteria will be established for various capacity levels, aircraft capabilities, and pilot preferences. Aircraft that are unable to maintain the required separation standard will execute a missed approach and return to the queue.
- Required Time of Arrival – Initial operations will include assignment of RTA windows to maintain safe separation distances. Pilots requesting approach will be assigned an RTA window that consists of an arrival fix, an approach path or procedure, a clearance "window", and instructions to maintain separation from other aircraft in the self-controlled area.

H 1.2 Definition of terms (See Introduction)

H 1.3 Significant changes from current operations, procedures, or policies

H. 1.3.1 For flights entering self-controlled areas from traditional controlled airspace, controllers transfer separation authority to pilots where special arrival and departure procedures have been established. To employ these procedures, pilots and their aircraft must meet specified requirements regarding training and equipment. This transfer of separation authority is similar to pilots accepting responsibility for separation on visual approaches under IFR. In this case, pilots would be authorized to maintain separation from an aircraft previously cleared into the SCA or to meet an RTA requirement.

H 1.4 Key Assumptions

- VFR traffic will be operating concurrently with HVO traffic in VMC conditions, and all pilots would have see-and-avoid responsibilities when in VMC, as they do currently.
- In IMC, traditional IFR aircraft can access the airport using procedural separation. The IFR aircraft will be cleared by ATC when no HVO-equipped aircraft are operating in the SCA, and no other aircraft will be cleared by ATC to enter the SCA until the IFR aircraft is has cleared the SCA or confirmed to have landed.
- All HVO aircraft operating in a self-controlled area (SCA) shall be on the same voice (CTAF) and datalink frequency.

H 2.0 Reserved for Functional Architecture

H 3.0 Description of concept of operations by phase of flight

H 3.1 Departure Phase

H 3.1.1 Prior to departure, a flight plan will be filed.

H 3.1.2. Departure sequence will be established by SATS sequencing automation.

H 3.1.3 Once cleared, pilots departing are responsible for separation from other aircraft in the SCA before they take the runway. (See LLM CONOPS for specific takeoff procedures and techniques.)

H 3.1.4 Departure procedures will generally conform to approved instrument departures unique to the particular airport environment.

H 3.1.5 If the departing aircraft is unable to begin takeoff roll within clearance window, pilot must taxi off the runway immediately, indicate the takeoff cancellation to SATS automation, and announce this on the CTAF.

H 3.2 En Route Operations (Not Applicable)

H 3.3 Descent and Arrival

Event sequences described below assume that all aircraft are equipped for high volume operations, with ATC performing their current function outside the self-controlled area.

H 3.3.1 Before entering the SCA, the pilot must establish communications with the SATS automation.

H 3.3.2 IFR traffic entering the SCA from controlled airspace are cleared into that airspace by an air traffic controller.

H 3.3.3 Pilots must request an approach and receive clearance from SATS automation. SATS automation provides the pilot with sequence information and/or an RTA window.

H 3.3.4 Pilots of HVO aircraft use aircraft controls, displays, and automation to conform to RTA constraints and standards and to maintain separation distance, (i.e., station keep) behind the traffic in front of them.

H 3.3.5 Pilot flies the approved approach procedure to missed approach, touch and go, or full stop landing.

H 3.3.6 If the arriving aircraft is unable to maintain separation distance, pilot must execute missed approach in order to re-enter the queue, indicate the missed approach via SATS automation, and announce this on the CTAF.

H 3.3.7 Separation is maintained based on flying the approved missed approach procedure to a missed approach holding point away from approaching aircraft or until radar contact is re-established.

H 3.3.8 When ready, pilot may request clearance to re-enter the queue or to an alternate destination.

H 3.4 Mixed equipage operations

H 3.4.1 Aircraft not equipped for HVO will not be cleared for an approach in an SCA until no other active traffic approaches are present in the SCA.

H 3.5 Non-Normal

H 3.5.1 For in-flight emergencies, the pilot experiencing the emergency shall follow procedures outlined in the pilot operating handbook, declare the emergency to SATS automation, and announce on CTAF. SATS automation will re-structure and re-assign priorities to accommodate needs of emergency aircraft.
H 3.5.2 For loss of surveillance capability (and therefore the ability to continue "electronic separation"), pilot must execute missed approach procedure, indicate the missed approach via SATS automation, and announce this on the CTAF. Pilot must contact ATC and re-enter controlled airspace.
H 3.5.3 For Loss of Data communications….
H 3.5.4 In the event of a failure or degradation of the GPS, landing and departure operations will conform to the published procedures (and associated minima) for remaining on-board navigation equipage.

H 3.6 Rare-Normal Operations

In the event of a hazardous weather condition in an SCA, the pilot is responsible for recognizing the situation and determining whether his HVO operation should be modified or terminated.

H 3.6.1 Human error (e.g. pilot and any controller)

Pilot commits potentially critical error, such as failure to maintain separation because of either aircraft performance limitation or pilot misunderstanding. Sufficient margin is designed into the separation standards and flight technical error to allow for corrective action. SATS architecture includes human error mitigation functionality (e.g. cockpit automation that warns pilot of deviations, advanced control systems provide envelope protection). Other aircraft with situation awareness will inform offending pilot and/or take appropriate corrective action.

LOWER LANDING MINIMA

L 1.0 Introduction

L 1.1 Overview

L 1.1.1 The general philosophy regarding the landing and takeoff of a SATS aircraft in the 2010 timeframe is to allow the single pilot to land in low ceiling and visibility conditions. The single pilot's situational awareness is enhanced on and near the airport.

L 1.1.2 The concept for SATS operations under reduced ceiling and visibility conditions, relies upon advanced controls, sensors (e.g. EVS), processors, cockpit displays (e.g. SVS), and procedures. Various combinations offered by these technologies provide for precise navigation and improved situational awareness.

L 1.1.3 Approach procedure design will exploit the full capability of modern GA aircraft both in terms of performance and avionics. Toward that end, we will examine approach profiles with positive horizontal and vertical guidance, varying glide path angles and course segments to maximize accessibility of airports while considering noise, land acquisition and airport infrastructure requirements, and other environmental and public safety issues.

L 1.2 Definition of Terms (See Introduction)

L 1.3 Significant changes from current operations, procedures, or policies

L 1.3.1 Reduced dependence on ground-based navigation and landing aids.

L 1.3.2 Increased dependence on differential GPS for precision approach path design.

L 1.3.3 The pilot identifies runway incursions by other aircraft, ground vehicles, and other obstacles on the runway, even on runways that are otherwise unmonitored, such as those at uncontrolled airports.

L 1.3.4 Pilot performance is increased as the takeoff and landing are easier to perform because of the "graphical" depiction of the runway and runway environment the pilot "sees".

L 1.3.5 Approach procedures with vertical guidance that allow low minima without attendant approach lighting systems.

L 1.3.6 Approved approach procedures that minimize obstacle clearance and runway protection zone (RPZ) requirements.

L 1.4 Key Assumptions

L 1.4.1 Lower landing minima approach procedures will include provisions for variations in approach speed.

L 1.4.2 LLM operations can be conducted without a re-design of runways and taxiways.

L 1.4.3 FAA will approve curved and/or segmented approaches to avoid terrain and obstacles at VFR airports and non-precision IFR airports.

L 2.0 Reserved for Functional Architecture

L 3.0 Description of concept of operations by phase of flight

L 3.1 Departure Phase

The ConOps begins as the single pilot taxies onto the active runway having been cleared for takeoff via HVO procedures . The departure phase ends when the pilot has taken off, climbed, and reached the point where minimum safe altitude for the SCA has been reached.

L.3.1.1 The pilot, with the aid of technology, is responsible for (1) observing the runway and spotting runway incursions and obstacles, and (2) aligning the aircraft with the runway.

L 3.1.2 Having confirmed that the runway is clear of obstacles, the pilot is now free to conduct a normal takeoff.

L 3.1.3 Upon reaching rotation speed, the pilot reverts to flying the aircraft by use of aircraft performance and navigation information provided by his on-board instruments. At rotation, when the aircraft nose points up relative to the runway, no further external visual information is available, and the single pilot continues the departure procedure, then transitions to the en route portion of the flight, under IFR.

L 3.1.4 Departure procedures will generally conform to standard instrument departures, or procedures unique to the particular airport environment.

L 3.2 En Route Operations (Not Applicable)

L 3.3 Descent and Arrival

For airport arrivals, the ConOps begins as the pilot begins a set of flight maneuvers or published procedures to stay clear of obstacles on approaching the airport runway. The LLM ConOps ends upon the pilot exiting the active runway, or if a full stop landing is not completed, then flying to a predetermined (approved) missed approach point.

L 3.3.1 The pilot flies the approach with assistance from airborne avionics and displays

L 3.3.2 The pilot's situational awareness with respect to the terrain and ground obstacles during the approach to the runway is enhanced by the display of a graphicalrepresentation of the terrain.

L 3.3.3 The pilot observes a graphical representation of the runway environment.

L 3.3.4 The pilot is provided cues to ensure he is aware when decision height is reached.

L 3.3.5 As the pilot descends and the distance to the runway decreases, the virtual representation of the runway is gradually augmented with direct or virtual visual image of the runway.

L 3.3.6 With runway environment cues, the pilot determines whether a safe landing can be completed.

L 3.3.7 The pilot either lands the aircraft and taxis off the runway onto a taxiway, or if landing conditions are not satisfactory to the pilot (not able to "see" the runway environment or obstacle on the runway), the pilot initiates missed approach and flies to a designated point (as indicated on the standard approach procedure). See HVO CONOPS for missed approach procedure when high volume operations are in effect.

L 3.3.8 The pilot is provided guidance in the event a missed approach needs to be executed.

L 3.4 Mixed equipage operations

Lower Landing Minima operations concentrate on the performance of a single aircraft. Mixed equipage operations are therefore not pertinent. However, the design of approach and departure procedures for SATS-equipped aircraft are not intended to preclude traditional operations at non-towered airports within the limits of that particular aircraft and pilot's performance/qualifications.

L 3.5 Non-Normal

L 3.5.1 For in-flight emergencies, follow procedures outlined in the pilot's operating handbook.

L 3.5.2 In the event of a failure of the LLM vision system, landing and departure operations will conform to the published procedures (and associated minima) for navigation equipage without LLM vision systems. If the ceiling and visibility are below the published approach minimum with that equipage, the aircraft will execute a missed approach and navigate to an alternate airport per ATC instructions and/or flight plan.

L 3.5.3 In the event of a failure or degradation of the GPS, landing and departure operations will conform to the relevant extraction procedures (and associated minima) for remaining on-board navigation equipage

L 3.6 Rare-Normal Operations

L 3.6.1 Adverse Weather

In the event of a hazardous weather condition in an SCA, the pilot will be responsible for assessing and determining whether continued LLM operations should be modified or terminated.

L 3.6.2 Pilot Errors

The pilot will be provided alerts and warning cues if aircraft is significantly displaced from glide slope or runway/pathway centerline.

SINGLE PILOT PERFORMANCE

S 1.0 Introduction:

S 1.1 OVERVIEW AND GENERAL PHILOSOPHY OF THE CONOPS:

S 1.1.1 The goal of the SPP operating capability is to enable SATS operations conducted by less experienced pilots to have a level operational performance, reliability, and safety equaling operations flown by experienced ATP rated pilots. This goal will be enabled by providing the pilot of a SATS aircraft has enhanced situational awareness, appropriate pilot workload and engagement, improved resource management (e.g. fuel, aircraft configuration), improved planning, improved error prevention and tolerance throughout all phases of flight and including HVO, LLM, and ERI operations. Collectively, these elements will significantly improve safety. Additionally, mission reliability is enhanced through increased operational capability in low-visibility conditions and improved decision-making, reducing the need to cancel, abort, or divert flights due to weather.

S 1.1.2 A goal of SPP is to provide the pilot with procedures and technologies that ensure all operations are safe, legal, and efficient. The general philosophy for meeting this goal is the use of human centered design and sophisticated human-centered automation (HCA) in conjunction with compatible airspace procedures defined in the HVO and LLM operating capabilities. HCA is designed to augment human skills and abilities rather than simply replacing them as in traditional automation. HCA views technology as a means of leveraging human strengths and managing human limitations as opposed to the human managing machine limitations as in much of today's automation. There are two major reasons for using HCA. The first is cost. Taking full advantage of the pilot's abilities (mental and physical) saves considerable costs in terms of the technology required to safely replace these assets. The second reason is that there are processes that humans can easily do, that no proven machine can do (e.g. the ability to reason inductively). So, for reasons of cost and capability, the human will be an integral part of the aircraft system.

S 1.2 DEFINITION OF TERMS

S 1.2.1 See introduction

S 1.2.2 HCA: Automation technology designed to augment human skills and abilities rather than simply replace them.

S 1.3 IDENTIFY SIGNIFICANT CHANGES FROM CURRENT OPERATIONS, PROCEDURES, OR POLICIES

S 1.3.1 Significant essential and critical functions currently the sole responsibility of the pilot may be shared between the pilot and technology or, if appropriate, may be performed solely by technology.

S 1.4 KEY ASSUMPTIONS:

S 1.4.1 By 2010, sophisticated but nevertheless algorithmic (i.e. deterministic) control and information processing functions can be cost-effectively executed with technology even for flight critical functions.

S 1.4.2 By 2010 more complex functions requiring human-like decision making skills can be supported by technologies such as knowledge-based systems. However, uncertainty about the performance of such technologies under all possible scenarios will preclude reliance on them for safety critical functions without effective human oversight.

S 2.0 Reserved for Functional Architecture

S 3.0 Description of Concept of Operations

S 3.1 Since the SPP operating capability covers all phases of flight the SPP CONOPS will be described in the form of functional requirements.

S 3.2 The SPP operating capability consists of the following functional requirements:

(Program note, For many of the following functional requirements, full mission implementations will not be possible within the limitations of the program, and a subset of functionality that provides a credible demonstration and basis for predicting the achievable performance of a full system will be selected by the SATS program partners. This selection is expected to be accomplished through an appropriate prioritization process by December of 2002.)

S 3.2.1 The single pilot shall be provided with the information and control authority needed to fulfill their responsibility as the final authority as to the operation of the aircraft.

S 3.2.2 The pilot (supported by the aircraft and its systems) shall have sufficient situational awareness to respond appropriately in credible situations (i.e. comparable to the actions and decisions that ATP rated pilots would choose). This awareness should include appropriate comprehension, integration, and prediction of elements during pre-flight and in-flight operations, such as:

a. The state of the aircraft and its systems
b. Surrounding air traffic and likely intentions
c. Airport information
d. Airspace information
e. Applicable weather information
f. Terrain and obstacles
g. Flight rules and procedures
h. Active and proposed clearances
i. Business and flight operations information and procedrues

S 3.2.3 The airplane/pilot system shall be designed to facilitate prevention, detection, and recovery from errors by either the pilot or the airplane systems.

S 3.2.4 The limited physical and cognitive abilities of the pilot shall be considered during normal, rare normal, and non-normal situations that have not been shown to be extremely improbable.

S 3.2.5 Entry into a condition unnecessary for normal operations and potentially hazardous (e.g. usual attitude, deviation from clearance) should require a deliberate action by the pilot

S 3.2.6 In the event of pilot incapacitation, the remaining occupants shall have a means of safely ending the flight that additionally does not create an undue hazard to other air traffic or persons and property on the ground.

S 3.3 The following describes how functions will generally be allocated between the pilot and the aircraft systems:

S 3.3.1 In general, the aircraft systems are allocated the following processes:

- Monitoring of data for consistency and validity

- Alerting and informing the pilot of deviations from expectations
- Alerting and informing the pilot of pending tasks
- Low-level guidance and control tasks
- Fusion and integration of data to present a perceptually consistent representation of the data
- Prognosis and prediction of current trends and situations,
- Information (memory) storage, search, and recall.
- Acting as a backup in the event of pilot error or incapacitation

S 3.3.2 In general, the pilot is allocated with the following processes:

- Defining strategic objectives and constraints
- Interpretation of information
- Selection from among alternatives
- Diagnosis of non-normality
- Acting as backup to the automation in the case of a machine error

EN ROUTE INTEGRATION

E 1.0 Introduction

E 1.1 Overview

The general philosophy regarding the En Route Integration operational capability is to focus on two areas:

E 1.1.1 Ensuring that the HVO, LLM, and SPP concepts, technologies and procedures are designed to facilitate appropriate interactions and transition of separation responsibility between air traffic controllers and SATS pilots and automation

E 1.1.2 Modeling to assess the impact of SATS-enabled traffic on NAS traffic density and flow.

Thus, there are no specific En Route Integration concepts that will be flight demonstrated as part of the baseline. However, impact of SATS procedures on the NAS will be mitigated through the following:

E 1.1.3Development of SATS Airport Operational Area concepts, technologies, and procedures that facilitate effective NAS integration, such as

E 1.1.3.1 clear procedures for arriving aircraft to obtain clearance from ATC to assume responsibility for self-separation once inside the SCA

E 1.1.3.2 procedure to ensure departing aircraft leaving the SCA are within the acceptance rate for ATC to approve IFR en route clearance as required

E 1.1.3 3 Completion of study with FAA to assess operational effectiveness of SATS concepts, technologies, and procedures with regard to interaction with en route air traffic control and traffic flow control technologies and procedures

E 1.4 Key assumptions:

In 2010, en route operations will largely be similar to what they are today.